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THE NUMBER OF YOUNG AT A BIRTH AND THE NUMBER OF NIPPLES IN PRIMATES

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INTRODUCTION

The world of today is populated by well over 2000 million human beings (Thompson, '46). It seems very doubtful that this figure is surpassed by the total numbers of all living non-human primates added together. In other words, the single species *Homo sapiens* is represented by a population which is probably in excess of the sum of the populations of the several hundred other recent primate species. On purely theoretical grounds one might have expected quite different conditions, particularly since most tropical regions could easily support much larger numbers of primates than do exist. Among primates man has acquired the longest period of fertility, but this period has its beginning at a much more advanced age in man than in any of the other primates. Because generations succeed each other at longer intervals in man than in apes, monkeys and lemurs, the former necessarily cannot increase his population as rapidly as can the latter. This may be illustrated in a theoretical fashion by the following examples: The period of fertility of the female lasts quite approximately 28 years in man, 16 years at best in chimpanzee and, probably, not over 7 years in the marmoset. On a rough average this period begins in the seventeenth year in man, in the ninth year in chimpanzee and in the third year in the marmoset. If it is assumed that under ideal conditions man as well as chimpanzee could produce one young each year and the marmoset 3 sets of twins every 2 years and that males and females are

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born in equal numbers, it can be calculated that in 45 years, or at the approximate average age at which female fertility ceases in man, the total offspring of the female descendants of an initial couple could amount to 64 in man, to 408 in chimpanzee and to more than 20 billions in the marmoset. The discrepancy between this potential and the acutal population growth is not nearly as striking in the case of man as it is in regard to the other primates. In actuality man is the only primate species which has increased its total population persistently and the non-human primates of today can at best hold their own in regard to numbers of individuals per species. The population growth of species is influenced by a multitude of physiological, pathological, psychological, ecological, and other factors. Which of these varied factors have changed in the course of human evolution to enable man to populate the earth and this in spite of the phylogenetic lengthening of the period between successive generations? To answer this interesting question fully we should be able to explain also why the rapidly maturing non-human primates do not increase in numbers.

The present paper contributes information on only one small, yet basic phase of the many-sided problem of population growth in primates. The rate of reproduction of a species is greatly dependent upon the number of young resulting from one pregnancy. In primates multiple births are the rule in some few of the lower forms, but occur only as exceptions, if at all, in the great majority of the species. The tendency for twinning in man has been regarded as a newly acquired character and as a consequence of modern man's "domestication" (Fischer, '30) which might significantly increase the rate of human propagation. That these views can no longer be maintained will be evident from this study which compiles the available information on multiple births among primates. Unfortunately this information is still quite fragmentary and in only few instances is it possible so far to indicate the relative frequency of plural offspring in non-human primates.

As shown by the title, this paper will deal also with the number of nipples in primates, another subject for which the information in the literature had not been systematically collected so far. That the number of nipples and mammary glands is closely related to the number of young at a birth has been claimed by many authors (e.g., Cuvier, 1805; Gegenbaur, 1898; Jones, '16). Bell ('23) had succeeded in breeding domestic sheep with 4 or more nipples which produced almost regularly twins or triplets. A chimpanzee with polymastia, described by Elder ('36), is the half-sister of twins and there are several reports on supernumerary nipples in mothers of human twins (e.g., Iwai, '07). Even though it has become known that the tendencies for plural births and for polymastia are independently inherited, it is not impossible that the frequency of supernumerary nipples in a normally uniparous species with usually only 1 pair of nipples might be indicative of the prevalence of twinning in the same species. In tree-shrews, which some recent authors (e.g., Simpson, '45) include among the primates, the number of young at a birth fluctuates between 1 and 4 and the number of nipples between 1 and 3 pair. Lyon ('13) had concluded that: "The number of offspring produced at one time by Tupaias probably varies with the species and directly with the number of mammae common to that species."

Most of the data for this study have been collected from the literature, some could be added from the writer's files of unpublished records, and further observations on the number and position of nipples in prosimians have recently been obtained by the writer in the Division of Mammals of the U. S. National Museum with the kind permission of Dr. R. Kellogg. Additional pertinent information is probably to be found in the literature, particularly in journals of local natural history societies, reports from zoological gardens, mammalogical accounts of expeditions, etc. Not many of such possible sources are readily accessible to the writer who has lacked the time for a systematic search in other libraries. As in most comprehensive bibliographic studies on primates the matter of

nomenclature often was the source of considerable difficulty. In order to avoid undue digressions and numerous footnotes, antiquated generic names have here been simply replaced by the equivalent terms, in general use today, without any comment. In the case of the family Hapalidae, which is notoriously in need of taxonomic revision, the writer has substituted a uniform terminology for the many different names used by the various authors quoted, a change which is justifiable as long as the original names can readily be found in the papers fully listed in the accompanying bibliography. It is also to be mentioned here that some authors have published generalized statements regarding the number of offspring or the number of nipples in prosimians without indicating whether or not they themselves had examined new material or had merely copied information from previously published reports. The species referred to and the number of specimens examined should be stated because, as will be shown in this study, the number of young at a birth as well as the number of nipples varies to a surprising degree in some genera of the Lemuroidea and this not only inter-, but also intra-specifically.

THE NUMBER OF YOUNG AT A BIRTH IN PROSIMIANS

Multiple offspring in mammals represents in general a more primitive condition than does single offspring. In monovulatory species, such as most of the primates, double or multiple ovulations can occur with varying frequency and are often interpreted as atavisms (e.g., Hamlett and Wislocki, '34). The number of young, resulting from one pregnancy, is primarily an inherited character and hence can differ markedly according to species and even race. Among domestic sheep, e.g., twins or triplets have been recorded in less than 3% of pregnancies in one race, whereas in over 90% of pregnancies in another race (Richter, '26). As already mentioned, Lyon ('13) has shown that the number of offspring at a birth varies in the treeshrews between 1 and 4 and seems to differ according to species. However, the number of young is not constant in at least some species of treeshrews, as the writer noticed while

removing the female reproductive tracts in a considerable series of *Tupaia chinensis* from one locality. In this material the number of embryos fluctuated between 2 and 4, though 3 existed in the majority of the cases.

Table 1 shows in condensed form the available information regarding the number of young at a birth in prosimians. Among these lower primates plural offspring occurs in only 4 genera, as far as known, and for only one of these genera

TABLE 1

The number of young at a birth in different genera of prosimian primates according to the literature and the author's records.

GENUS	PLURAL OFFSPRING	SINGLE OFFSPRING
Daubentonia		Elliot, '13 (1 case); Hill and Burne, '22 (2 cases)
Lemur	Heck, '16 (1 case of twins and 1 case of triplets); Jones, '29 (4 or more cases of twins); Bigalke, '32 (1 case of twins); Abel, '33 (1 case of twins) Total = at least 8 cases	Heck, '16 (6 cases); Heck, '29 (2 cases); Jones, '29 (8 or more cases); Stadie, '31 (15 cases); Bigalke, '32 (1 case); Abel, '33 (20 cases); Boulenger, '36 (2 cases); Schultz (2 cases) Total = at least 57 cases
Microcebus	Jones, '29 (quoting Shaw) "two and sometimes three at a birth"; Bluntschli, '39 "mostly 2 to 3, often 4 embryos"	
Chirogale		Jones, '29 (2 cases)
Indris		Milne-Edwards and Grandidier, 1875; Flower and Lydekker, 1891; Asdell, '46 (number of cases not stated)
Propithecus		Milne-Edwards and Grandidier, 1875; Flower and Lydekker, 1891; Asdell, '46 (number of cases not stated)
Loris	Hill, '25 "twins not uncommon"; Hill, Ince and Subba Rau, '28 "twins occasionally"	Hill, '33 (3 cases); Hill, '42 (3 cases)
Nycticebus		Elliot, '13 (number of cases not stated); Heck, '16 (1 case); *Catalogue*, '21 (much embryological material); Fischer, '29 (1 case); Hill, '37a (3 cases); Schultz (3 cases)
Perodicticus		Heck, '16 (1 case); Hollister, '24 (1 case); Schultz (3 cases)
Galago	Shortridge, '34 (several cases of twins); Bigalke, '37 (1 case of twins); Lowther, '40 (1 case of twins); Hill, '41 (several cases of twins)	Heck, '16 (number of cases not stated); Hollister, '24 (many cases); Peter, '33 (1 case); Shortridge, '34 (many cases); Allen and Loveridge, '42 (1 case); *Report*, '46 (1 case); Schultz (1 case)
Tarsius		Cuming, 1838 (1 case); *Catalogue*, '21 (much embryological material); Clark, '24 (8 cases); Cook, '39 (1 case); Schultz (1 case)

(Microcebus)[1] is plural offspring the rule. In the other 3 genera *(Lemur, Loris* and *Galago)* single young have been observed more frequently than 2 or more young at a time. The type of twinning of the latter is unfortunately not known. In view of the great lack of constancy in the number of young at a birth in such groups as *Lemur* and *Galago*, as well as on account of the general scarcity of data, it seems quite reasonable to expect at least occasional plural offspring in some of the genera represented in table 1 by only single young. It is evident from the table, however, that in prosimians the specialized condition of single offspring is decidedly more prevalent than are multiple births. In the genus *Lemur*, e.g., single young have been recorded for at least 57 cases, whereas "more than one young at a time" for only 8 or a few more cases. It is quite possible that the frequency of twins is significantly greater in some species than in others of the same genus, but this cannot be demonstrated on the basis of available data. There are several cases known of *Lemur mongoz*, which had single young, and not one with plural offspring, but *Lemur macaco, L. catta, L. variegatus,* and *L. albifrons* all contribute cases to both main columns in table 1 and this without clear preference for the column of plural or that of single offspring. According to the reports consulted by the writer, *Lemur rubiventer* had single offspring in 3 instances, but Asdell ('46), without stating the number of cases nor the source of his information, lists this species as having "usually 2" young at birth. Heck ('16) mentions a pair of *Lemur variegatus* which produced a single young one time, twins another time and triplets the last time. Further details regarding the cases from the literature, though mostly disappointingly meagre, can be found in the original publications referred to in the table. The 10 new cases, which the writer is able to contribute, are all instances of single offspring. The 2 lemurs are of the species *Lemur fulvus* and *L. mongoz*, 2 of the *Nycticebus* be-

[1] Bluntschli ('39) found in *Microcebus* at early stages of development "almost always 2 germinal vesicles in each of the 2 uterine horns" and states that mostly 2 to 3, often even 4 embryos are encountered at later stages.

long to the species *borneanus* and a third to *malaianus*, 2 pottos are *Perodicticus potto* and one is a *P. ibeanus*, the bush-baby is *Galago garnetti*, and the tarsier *Tarsius philippinensis*.[2]

THE NUMBER OF YOUNG AT A BIRTH IN HAPALIDAE

As shown by the data [3] in table 2, the occurrence of twins represents the rule in the family Hapalidae, twins having been found in 78% of the cases. In 17% of the cases there were single young and in the remaining 5% triplets. The available information is far too scanty to permit any conclusion regarding possible generic or specific differences in the frequency of twinning. All the cases of single young, which could be tabulated, refer to offspring born in captivity and not to embryos in utero, collected from wild-shot specimens. It is possible that some of these cases had started as twins and that only one twin survived, the other having died in utero and become resorbed. Wislocki ('39) has described a specimen of *Oedipomidas* the uterus of which contained "a single, well-developed, viable fetus, besides a very much smaller macerated twin fetus." Because a considerable proportion of the cases of multiple offspring include males and females and on the basis of careful examinations of a number of pregnant uteri and the accompanying ovaries by Hill ('26, '27) and by Wislocki ('39) the latter author concluded "that

[2] The information, represented by these new cases, was obtained from various sources. Dr. W. M. Mann kindly permitted the writer to mention that at the National Zoological Garden in Washington single young had been born to a pair of lemurs and to one of pottos. The late Dr. H. Fox had generously given to the author the single deadborn baby of a *Galago* from the Philadelphia Zoological Garden, and Dr. J. Fulton had contributed the body of a female potto which had miscarried a single large fetus. A living slow loris with its newborn baby had been received by the writer in British North Borneo through the kindness of Mr. H. G. Keith, Chief Conservator of Forests. The remaining data are based upon the author's notes on material in the collections (and catalogues) of the U. S. National Museum, The Wistar Institute of Anatomy and the Department of Anatomy of the University of Zurich.

[3] The only new case which the writer could add is that of a single, full-term fetus of a marmoset which had died during parturition at the Philadelphia Zoological Garden, the fetus being in the author's collection.

the majority of all marmoset twins must be dizygotic.'' The suggestion has been offered by Hamlett and Wislocki ('34) that ''the marmosets may have already passed through the monovular condition which is still found in all other Primates

TABLE 2

The number of young at a birth in marmosets and tamarins according to the literature. The figures refer to the number of the recorded pregnancies.

SPECIES	AUTHOR	OFFSPRING:		
		Single	Twins	Triplets
Marmoset (spec.?)	Geoffroyi Saint-Hilaire et Cuvier, 1824			1
Marmoset (spec.?)	Rudolphi, 1828		1	
Marmoset (spec.?)	Breschet, 1845		1	
Hapale (spec.?)	Heck, '16		2	
Hapale jacchus	Heck, '16		3	1
Hapale jacchus	Hill, '26 and '32; Hill and Hill, '27		3	
Hapale jacchus	Lucas, Hume and Smith, '27		2	
Hapale jacchus	Marik, '31		1	
Hapale jacchus	Zuckerman, '31		2	1
Hapale jacchus	Fitzgerald, '35	1	3	
Hapale jacchus	Zukowsky, '40/'41		1	
Hapale penicillata	Stadie, '31		1	
Hapale argentata	Zukowsky, '40/'41		1	
Hapale pygmaea	Zukowsky, '37	2		
Hapale pygmaea	Zukowsky, '40/'41	3		
Oedipomidas oedipus	*Nachrichten*, '32		1	
Oedipomidas bicolor	Zukowsky, '37	1		
Oedipomidas bicolor	Zukowsky, '40/'41	2		
Oedipomidas geoffroyi	Wislocki, '39		19	
Oedipomidas geoffroyi	Schultz	1		
Leontocebus rosalia	Bigalke, '35/'36		1	
Leontocebus rosalia	Zukowsky, '37		2	
Leontocebus rosalia	Zukowsky, '40/'41		2	
Total of cases = 59		*10*	*46*	*3*

and may have evolved a regular process of fraternal twinning as a specialization superimposed upon the typical Primate condition.'' In view of the fact that plural offspring is the rule in at least one prosimian genus and common in several

other genera and also because Beattie ('27) has found indications of partial persistence of the primitive, prosimian, bicornuate uterus in some marmosets, it would seem more justifiable to assume that the diovulatory condition of the Hapalidae represents the retention of an old feature, rather than a new acquisition.

TABLE 3

Cases of twins among Cebidae, Cercopithecidae and Pongidae.

SPECIES	AUTHOR	REMARKS
Alouatta seniculus	Schultz, '21	monozygotic fetuses
Alouatta palliata	Schultz	dizygotic newborns
Macaca irus	Selenka, 1892	dizygotic fetuses
Macaca irus	Bolk, '26	double monster
Macaca mulatta	Hartman, '43	double monster
Papio porcarius	Fitzsimons, '19	2 cases of twins
Papio hamadryas	Heck, '16	captive-born
Papio hamadryas	Abel, '33	dead-born ♂♂
Cercopithecus pygerythrus	Fitzsimons, '19	2 cases of twins
Cercopithecus albigularis	Wislocki, '39	dizygotic fetuses
Cercopithecus sabaeus	Stott, '46	captive-born
Nasalis larvatus	Schultz, '42	dizygotic fetuses
Chimpanzee	Yerkes, '34	dizygotic newborns
Chimpanzee	Armand Denis	captive-born ♂♂
Chimpanzee	W. L. Westley	dizygotic infants

TWINS IN CEBIDAE AND CATARRHINE PRIMATES

In table 3 are listed 17 cases of twins in representatives of the families Cebidae, Cercopithecidae and Pongidae. Three sets are monozygotic, or true, twins and 6 are dizygotic, fraternal twins. In the remaining cases the type of twinning is unfortunately unknown. The 3 new cases, not previously recorded in the literature, are: (1) male and female twin newborns of a howling monkey, collected by the writer in Central America; (2) male chimpanzee twins born at the Anthropoid Ape Research Foundation at Dania, Florida, whose bodies, after their deaths in early infancy, had generously been sent to the writer by Mr. Armand Denis, who

has permitted publication of this incidence of twinning; (3) the following information on chimpanzee twins, obtained from Mr. W. L. Westley after his recent return from West Africa: near Blama, Sierra Leone, Mr. Westley had shot a chimpanzee mother of male and female, "quite helpless" young which were subsequently nursed by a native woman, but died soon afterwards. From the more detailed accounts it appears exceedingly unlikely that this constitutes a case of kidnapping, such as has been reported for a macaque by Hartman ('38).

It is as yet impossible to determine with any degree of finality the relative frequency of plural births among the primates listed in table 3. It seems desirable, however, at least to record here the known numbers of single births in the same types of primates, so that future observations can readily be added until the series become adequate for obtaining reliable figures on the proportion between single and plural births. The author has examined a total of 25 fetuses or newborns of howling monkeys, including the 2 sets of twins in table 3. This would indicate a percentage frequency of twinning in *Alouatta* of 8.7. It is readily admitted, however, that a much larger series of records is needed for concluding that twins may be quite common among howling monkeys. In macaques, which are very frequently bred in captivity, only 3 cases of twinning have become known so far.[4] Through the kindness of Dr. G. Corner, director of the Carnegie Laboratory of Embryology, the author has learned that in the macaque colony of that laboratory there have occurred 188 pregnancies up to the present time. Among these there has been only one case of (incomplete) twinning — the double monster, recorded by Hartman ('43). Thus, quite tentatively, one may give the percentage frequency of twinning in macaques as 0.5. Abel ('33) has collected information on 85 births among baboons in various European zoological gardens

[4] Selenka (1892) has labelled his twin specimens "*Cercocebus cynomolgus*," but refers to them also as "gemeiner Javaaffe"; he had never collected in countries containing *Cercocebus*. There can be no doubt that he had dealt with the Java macaque, *Macaca irus*.

which contained only one case of twins. To these may be added the instance of captive-born baboon twins, mentioned by Heck ('16). It can thus be concluded that twinning resulted in 2 out of 86 pregnancies among baboons, or with a percentage frequency of 2.3. Regarding guenons Stott ('46) mentions that the case of twinning, he has published, is the first among "more than 40 births of 8 different species of *Cercopithecus* monkeys [which] have been recorded in the San Diego Zoo." Based upon this information the very tentative percentage occurrence of twins among guenons lies above 2. The total of all observed pregnancies or births in chimpanzees most likely does not exceed 100, yet 3 cases of twins in chimpanzees have become known. It seems significant that twins among monkeys and apes have been found particularly in the forms which are especially numerous in nature as well as in collections and which breed most readily in captivity, i.e., macaques, baboons and chimpanzees. So few gravid uteri or observed births of other monkeys and apes have been recorded so far that the finding of twins is merely a matter of luck, as in the case of the proboscis monkey twins, listed in table 3, which were obtained from one out of only 2 gravid females of this species, collected by the writer.

In man the percentage frequency of plural births is somewhere near 1.28, a value found in the population of the United States (Strandskov, '45). It is quite possible that eventually it will appear that twinning occurs in most or all other catarrhine primates with similar, if not at times higher, frequency. In view of the known occurrence of plural births in a wide variety of primates from all major groups, we have to abandon Fischer's theory that twinning in man is a newly acquired character. The claim that the frequency of plural births may be on the increase in man has not been supported by facts and does not appear probable.

THE NUMBER OF NIPPLES IN PROSIMIANS

The normal number of nipples varies enormously among placental mammals, namely from only 2 in numerous forms

to 22 or even 24 in the primitive insectivore *Centetes* which has as many as 21 young at one time. Intraspecifically the number of nipples can also have a wide range of variations. In domestic pigs, e.g., there may be as few as 8 or as many as 18 nipples, 12 occurring in 30 to 40% of the cases (Bresslau, '20). Among prosimians one finds only 1, 2 or 3 pair of nipples. From the scattered literature on this subject it appears that in some prosimian genera the number of nipples is not constant. Most of the published reports give merely general statements regarding the number and position of the nipples in a particular genus without mentioning species or number of specimens examined. The writer has studied a total of 72 prosimian primates for the number and location of their nipples.[5] The results, together with the findings from the literature, are given in table 4. The general position of the nipples on the trunk is apparent from the table, but will here receive no further discussion. It may merely be mentioned that "axillary" nipples are here listed for simplicity's sake with "pectoral" ones, "inguinal" nipples with "abdominal" ones, and that in some instances the lower "pectoral" nipples are situated at the very border between the thoracic and abdominal regions. In male *Myoxicebus* "pectoral" nipples have migrated to the shoulder according to Beddard (1884, '20).

The aye-aye is distinguished among all primates by possessing 2 inguinal nipples and no others and this in every case which has been reported so far. In the genus *Lemur* one finds most frequently only 1 pair of nipples, being situated on the chest; not uncommonly there are 2 pair of pectoral nipples, and in 3 instances 3 pair of nipples have been found. The latter cases all belong to the species *L. variegatus*, but another specimen of the same species has only 2 pair of nipples. Of 7 *L. fulvus*, examined by the writer, one has 2 pair of nipples and the other 6 have only 1 pair. The excep-

[5] Fully adult females with well-developed mammae and older fetuses or newborns with thin hair coat have been selected for most genera. In males and immature females it is often difficult to find the small nipples in the dense fur.

and the author's observations.
(sp. = specimens)

GENUS	TWO PECTORAL AND ONE ABDOMINAL PAIR	ONE PECTORAL AND ONE ABDOMINAL PAIR	ONLY ONE ABDOMINAL PAIR	TWO PECTORAL PAIR	ONLY ONE PECTORAL PAIR
Daubentonia			Peters, 1866; Owen, 1868; Flower and Lydekker, 1891; Leche, 1897; Gegenbaur, 1898; Elliot, '13; Pocock, '22; Weber, '28; Schultz (1 sp.)		
Lemur	Heck, '16 (1 sp.); Schultz (2 sp.)			Peters, 1866; Owen, 1868; Gegenbaur, 1898; Schultz (4 sp.)	Gervais, 1854; Flower and Lydekker, 1891; Bonnet, 1893; Leche, 1897; Elliott, '13; Weber, '28; Schultz (8 sp.)
Myoxicebus		Flower and Lydekker, 1891; Beddard, '20; Weber, '28		Schultz (2 sp.)	Bonnet, 1893
Microcebus	Gervais, 1854; Bonnet, 1893	Peters, 1866; Owen, 1868; Bonnet, 1893; Leche, 1897; Gegenbaur, 1898; Elliot, '13			
Chirogale					Bonnet, 1893
Indris					Flower and Lydekker, 1891; Leche, 1897; Weber, '28; Schultz (1 sp.)
Lichanotus					Bonnet, 1893
Propithecus					Schultz (5 sp.)
Loris		Peters, 1866; Owen, 1868; Gegenbaur, 1898; Hill, '25		Bonnet, 1893; Leche, 1897; Schultz (2 sp.)	Flower and Lydekker, 1891; Weber, '28
Nycticebus	Schultz (1 sp.)			Schultz (17 sp.)	
Perodicticus	Schultz (5 sp.)				
Galago	Peters, 1866; Bonnet, 1893; Schultz (12 sp.)	Flower and Lydekker, 1891; Johnson, '06; Weber, '28		Owen, 1868; Gegenbaur, 1898; Schultz (3 sp.)	
Tarsius	Schultz (5 sp.)	Peters, 1866; Owen, 1868; Bonnet, 1893; Leche, 1897; Gegenbaur, 1898; Jones, '16; Woollard, '25; Weber, '28; Schultz (4 sp.)			

tional *Nycticebus* in the table is of the species *N. cougang;* it has 3 pair of well-developed nipples, but in another specimen of the same species there are only 2 pair of nipples. Of *Galago senegalensis* the author has seen 1 specimen with only 2 pair of nipples and 3 specimens with 3 pair of nipples. The 5 specimens of *Tarsius* which have 3 pair of nipples are all from Mindanao and the other tarsiers, seen by the writer, come from different localities. The tarsiers, referred to in the literature as possessing only 2 pair of nipples, are of unknown species. Incidentally, in the Philippine tarsiers all 6 nipples are equally large and for one of these specimens the collector, the late Edgar A. Mearns, had recorded that the "3 pairs of mammae are filled with milk." In many other prosimians the writer has found no noteworthy difference in size in the 6 nipples and in a few cases it was possible to detect mammary glands connected with each of these nipples. It is certain, therefore, that one pair of such nipples has persisted not merely as anchoring or hafting structures, for the young to grasp, as has been claimed. From the above notes it can be concluded that the number of nipples can vary within a species, but the average number of nipples can differ significantly in different species of one and the same genus. Only 1 pair of nipples, situated on the chest, the advanced condition typical for all simian primates, occurs among prosimians in the subfamily Indrisinae and, in part of the cases only, in the genera *Lemur*, *Myoxicebus* and *Loris*. According to a single report, *Chirogale* also has only 1 pair of pectoral nipples, but it remains to be seen whether this is the rule or an exception. The primitive condition of 2 or even 3 pair of nipples is more frequently encountered among prosimians than the specialized reduction to only 1 pair of nipples.

In comparing table 4 with table 1 it is evident that the number of nipples is not necessarily related to the number of young at a birth. *Daubentonia*, *Chirogale*, *Indris*, and *Propithecus* which have single offspring also have only 1 pair of nipples; *Microcebus* with its plural offspring possesses 2 or 3 pair of nipples. In *Nycticebus*, *Perodicticus* and *Tarsius*,

however, only single young have been observed so far, yet they all possess 2 or 3 pair of nipples. In the 3 genera, *Lemur*, *Loris* and *Galago*, which can have single or plural offspring (see table 1), the number and location of the nipples is particularly variable (see table 4).

SUPERNUMERARY NIPPLES IN SIMIAN PRIMATES

In the entire suborder of simian primates 2 pectoral nipples represent the normal condition. Additional nipples, however, have been found in a total of 40 monkeys and apes and in a great many human beings. The non-human cases are listed in table 5. The series is composed of 1 marmoset, 5 capuchin monkeys, 20 macaques, 3 baboons, 1 guenon, 2 red guenons, 1 gibbon, 1 siamang, 1 orang-utan, and 5 chimpanzees,[6] i.e., of representatives of all major groups, except the Semnopithecinae. Only 1 supernumerary nipple exists in each of 30 cases, 2 in each of 8 cases, 4 in 1 case, and of the remaining case, a marmoset, it is merely known that it showed polymastia. The single supernumerary nipples are located on the right side in 10 instances and on the left side in 17 instances. As far as can be determined from the published information, all these extra nipples are situated on the chest and never on the abdomen, but in all except 2 specimens the supernumerary nipples are below the normal pair. The 2 exceptions consist of 1 red guenon which has an extra nipple above the nearest normal one and of the gibbon with an additional nipple lateral to the nearest normal one. In many of these cases the supernumerary nipples are practically as large as the normal ones, particularly whenever the former nipples are located a considerable distance away from the latter. If, however, an extra nipple is found in close proximity to a normal one, it is usually of small size. In such (rare) cases the 2 nipples evidently belong to one and the same glandular area and, in all likelihood, represent merely the result of localized twinning which can occur

[6] In a recent letter to the author Dr. L. H. Matthews of the Department of Zoology of the University of Bristol states that he has in press a report on functional, supernumerary nipples in a chimpanzee.

also in many other bodily structures, such as digits, teeth, etc. This interpretation of the relatively few cases with accessory nipples close to normal ones becomes more probable in view of the fact that the developmental duplication of a nipple is at times associated with other congenital abnormalities. This

TABLE 5

List of cases of supernumerary nipples in simian primates.

PRIMATE	NUMBER OF CASES	LOCATION OF EXTRA NIPPLE	AUTHOR
Callithrix spec.?	1	?	Schickele, 1899
Cebus capucinus	2	1 r., 1 l.	Schickele, 1899
Cebus fatuellus	1	l.	Schickele, 1899
Cebus hypoleucus	1	2 r. & 2 l.	Schickele, 1899
Cebus capucinus	1	l.	Schultz
Macaca "cynomolgus"	1	unilateral	Schickele, 1899
Macaca mulatta	1	l.	Hartman, '27
Macaca mulatta	1	l.	Zuckerman, '35
Macaca mulatta	13	6 l., 5 r., 2 r. & l.	Speert, '42
Macaca mulatta	1	r. & l.	Schultz
Macaca sinicus	1	l.	Sutton, 1889
Macaca sinicus	1	l.	Hill, '37b
Macaca nemestrina	1	r.	Zuckerman, '35
Papio porcarius	3	2 unilateral, 1 bilateral	Zuckerman, '35
Cercopithecus schmidti	1	r. & l.	Beddard, '01
Erythrocebus patas	1	l.	Sutton, 1889
Erythrocebus patas	1	l.	Hill, '37b
Hylobates lar	1	l.	Coolidge, '43 and Schultz, '44
Symphalangus syndact.	1	r.	Coolidge, '43
Orang-utan	1	l.	Owen, 1868
Chimpanzee	1	r. & l.	Coolidge, '33
Chimpanzee	2	r. & l.	Elder, '36
Chimpanzee	1	r.	Nestur, '36
Chimpanzee	1	r.	Coolidge, '43

has been reported for a series of cases in man by Boenheim ('19). The macaque and the gibbon in which the writer has found accessory nipples both possess also supernumerary digits. In the great majority of the cases of supernumerary nipples in simian primates these structures are located about

as far from the pair of normal nipples as the 2 pair of normal pectoral nipples lie apart in many prosimian primates. There can be little doubt that here one deals with an atavism, i.e., the re-appearance in occasional simian primates of a developmental process which is normal in many prosimian forms. In some instances the prosimian plan of mammary development is repeated incompletely, producing merely the nipple in females and males and this often on 1 side only, but not infrequently one or more entire supernumerary mammary glands are formed which become functioning under suitable conditions. Numerous such cases have been found among human beings.

The relative frequency of supernumerary nipples among simian primates can not yet be determined on an adequate basis, except for man and, possibly, the macaque. The incidence of such nipples fluctuates apparently to a marked extent among different human groups. According to Speert ('42), who has briefly reviewed the pertinent literature, the general average percentage frequency lies probably not far above 1. The same author states that among approximately 1000 rhesus monkeys which "have passed under scrutiny in the Carnegie and associated laboratories" there were 14 cases of supernumerary nipples, giving the incidence of this condition as 1.4%. The writer, who has carefully examined and measured a total of 159 dead macaques of various species and ages, has found supernumerary nipples in only 1 specimen, a rhesus monkey. The latter is one of 89 *Macaca mulatta* in the writer's series, indicating a percentage frequency of 1.1, or again a value very similar to that typical for man. The 3 cases of supernumerary nipples in chacma baboons, recorded by Zuckerman ('35), were found among 14 females shot out of 1 pack of baboons. This astonishingly high incidence Zuckerman regards as a local occurrence, due to inbreeding, since polymastia is of a hereditary nature. Schickele (1899) mentions that he had found his 5 cases of supernumerary nipples in New World monkeys in a series of only 22 of these primates. This is unquestionably quite exceptional. The

writer could discover only 1 instance of an extra nipple among 44 wildshot capuchin monkeys and not a single case among more than 200 specimens belonging to other platyrrhine genera. Coolidge ('33) found polymastia in only 1 chimpanzee after having examined the hides of over 600 great apes (number of chimpanzees alone not stated). Among 114 dead chimpanzees, studied by the author, there is not a single case of supernumerary nipples, but a total of 6 cases in chimpanzees have become known so far. The total of all chimpanzees, carefully examined by investigators inclined to report possible extra nipples, is unknown, but can hardly be far in excess of 600. Thus, quite tentatively, one might predict that the average percentage frequency of polymastia in chimpanzees will eventually be found somewhere near 1.

In comparing table 5 with table 3 it is seen that cases of supernumerary nipples have been recorded for nearly all the genera in which cases of plural births have also been found. Both conditions are known to occur among macaques, baboons, guenons, and chimpanzees which are the groups represented in our collections in specially large numbers. As other groups can be examined in more extensive series it will be shown, most likely, that the 2 primitive conditions of multiple offspring and of supernumerary nipples have not entirely disappeared in any division of the suborder Simiae. It is surprising that so far only 1 case of polymastia has been found in marmosets which usually have twins. However, in the dense fur of these small animals nipples can readily be overlooked, unless carefully searched for.

SUMMARY

On the basis of the previously scattered information in the literature and the writer's records and new observations the following more or less tentative generalizations seem justified regarding the number of young at a birth and the number of nipples in primates:

The primitive condition of multiple offspring occurs, as far as known, in only 4 prosimian genera (*Lemur*, *Microcebus*,

Loris, and *Galago)* and is typical for only one of these *(Microcebus)*. In the other 3 genera plural births have been recorded for only a minority of the cases. In the remaining prosimian genera single births are the rule according to all present information. In the family Hapalidae triplets have been found in 5% of the cases, twins in 78% and single offspring in the remaining 17%. Seventeen cases of twins [7] have become known among representatives of the families Cebidae, Cercopithecidae and Pongidae. The incidence of plural offspring in these groups can not yet be determined, but it seems probable that it equals or surpasses that existing in man.

The primitive character of 2 or even 3 pair of nipples is among prosimians more frequent than the specialized reduction to only 1 pair of nipples. The latter condition seems to be constant in the entire subfamily Indrisinae, which has only 1 pair of pectoral nipples, and in *Daubentonia*, which is characterized by a single pair of inguinal nipples. Six nipples have been found in specimens of *Lemur*, *Microcebus*, *Nycticebus*, *Perodicticus*, *Galago*, and *Tarsius*. The number of nipples can vary markedly in many prosimian genera, at times even intraspecifically. Among monkeys and apes supernumerary nipples have been found in a total of 40 cases, representing most major groups. These extra nipples lie usually on the chest below the normal pair of nipples and correspond to the lower pair of pectoral nipples, common among prosimians. As far as can be determined quite tentatively, the general percentage frequency of true supernumerary nipples is very similar in monkeys, apes and man and lies probably not far above 1.

The potentialities for producing more than 1 young at a birth and for developing more than 2 nipples, prevalent in some prosimians, still persist among all groups of simian primates, though appearing in only small percentages of cases, except in the Hapalidae which have plural births as a rule.

[7] After proof of this paper had been returned the author was kindly informed by Mr. Bean, director of the Brookfield Zoo of Chicago, that in a large colony of baboons *(Papio doguera)* at his zoo there have been so far about 35 pregnancies, including one instance of twins.

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RH TESTS ON BASQUES LIVING IN ARGENTINA.— So far as is known, all the peoples of Asia and North Africa have very high *Rh*-positive frequencies, but until recently no source for the hypothetical *Rh*-negative element could be found. Etcheverry [Dia med., *17:* 1237 (1945)] has now published the results of *Rh* tests on 128 [since raised to 250] persons of Basque descent living in the Argentine, of whom 33.6 [since raised to 35.6] per cent are *Rh*-negative . . . this remarkable observation [makes it seem] highly probable that the *d* gene in Europe is mainly derived from ancestors akin to the modern Basques. An examination of the full *Rh* genotypes and other blood group antigens of as many Basques as possible, is much to be desired, and steps are being taken to secure the necessary specimens.— A. E. Mourant. The blood group of the Basques. Nature, vol. 160, no. 4067, Oct. 11, 1947, pp. 505–506.

LONG-TERM STUDY OF MALOCCLUSION.— The Forsyth Dental Infirmary for Children of Boston has reeived from the Charles H. Hood Dairy Foundation a 5-year grant of $25,000 in support of a long-term study of growth and development of the teeth and jaws in relation to the problem of "malocclusion" of the human dentition. The following members of the Forsyth staff are participating in the study: Dr. C. F. A. Moorrees, orthodontist; Mr. Stanley M. Garn, physical anthropologist; and Dr. B. O. Hurme, director of clinical research.

An Advisory Committee for the study consists of: Dr. George B. Wislocki, James Stillman Professor of Comparative Anatomy, Harvard Medical School; Dr. Harold C. Stuart, Professor of Maternal and Child Health, Harvard School of Public Health; Dr. Earnest Hooton, Professor of Anthropology, Harvard University; Dr. Roy O. Greep, Associate Professor of Dental Science, Harvard School of Dental Medicine.

The study will attempt to evaluate the many variables which influence the structure and function of the teeth and jaws and will stress body build, growth rate, inheritance, socio-economic status, nutritional and psychological factors.

THE INFLUENCE OF MECHANICAL FACTORS ON THE DEVELOPMENT AND STRUCTURE OF BONE

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SEVENTEEN FIGURES

The generally accepted view of the nature of the external form and of the internal structure of bone is expressed as Wolff's Law (Wolff, 1892), the usual statement of which is: "Every change in the form and function of a bone, or of function alone, is followed by certain definite changes in the internal architecture and equally definite secondary alterations in the external conformation in accordance with mathematical laws."

This Law has been subjected to considerable criticism by those who adhere to a primary or inherent growth pattern theory as the causative factor in the production of bone form and architecture. Wolff, however, referred to the final functioning structure; he made no reference to the processes of growth or to the means by which the final structure is formed, and though the processes of growth or repair (that is, deposition and absorption of bone) must be involved, he claimed only that their specific direction is determined by the function, not they themselves, and he left growth, as growth, an independent vegetative part of osteogenetic tissue with all the genetic direction peculiar to it.

A radiological investigation has been made of the structure and development of the cortical and cancellous bone in the femur, both in the human subject at different periods of life,

and in animals representing successive evolutionary stages. The internal architecture and external shape of the femur at various stages of human development have been correlated with the appearance of the corresponding groups of bony trabeculae on the phylogenetic scale, and the dependence of the architecture and external shape on changing mechanical requirements has been demonstrated both in ontogenetic and phylogenetic development.

Femora were obtained from fetuses whose ages were 3 months, 5 months, 7 months and 8 months; from infants and children whose ages were 1 month, 1 year, 15 months, 2½ years, 4 years, 8 years and 10 years; and one adult bone was used to show the final form. To obtain clear radiographs (figs. 6 to 13) the anterior and posterior surfaces of many of the femora were removed, leaving thin coronal sections. The radiographs were enlarged in the case of the younger bones to show details more clearly.

The radiographs showed that in the fetal and early postnatal bones there are, in the ossified part of the structure, longitudinal bars or trabeculae of bone which are more or less parallel to one another and which exhibit only a slight divergence towards the extremities. Shortly before the age of 12 months, corresponding with the onset of increased muscle contraction and standing and walking, there is absorption of the fetal pattern and complete reformation of the cancellous bone on a "cross-braced" plan, as in the adult bone, to withstand the strains and stresses of walking.

There is a continuous change in the form of the bony material of the femur throughout the growth period. As the bone enlarges in both longitudinal and transverse dimensions, the processes of absorption and reconstitution of the bone element proceed together in the compact and cancellous tissues. The architecture of the internal trabeculae undergoes a change so that the original almost parallel trabeculae of the fetal and early postnatal femora are absorbed by the end of the first year and the new cross-braced systems of bony trabeculae in the head and neck are laid down. Further with the progressive

decrease in the angle of the neck throughout childhood, there is simultaneous absorption and deposition of bone, on mechanical principles, in the correct places, both in the external compact tissue of the neck and in the internal trabeculated plates. The internal architectural features conform to the change in external form while still retaining their general pattern and efficiency as supporting structures.

The cross-braced system of curved trabeculated plates which has appeared in the neck region before 1 year of age

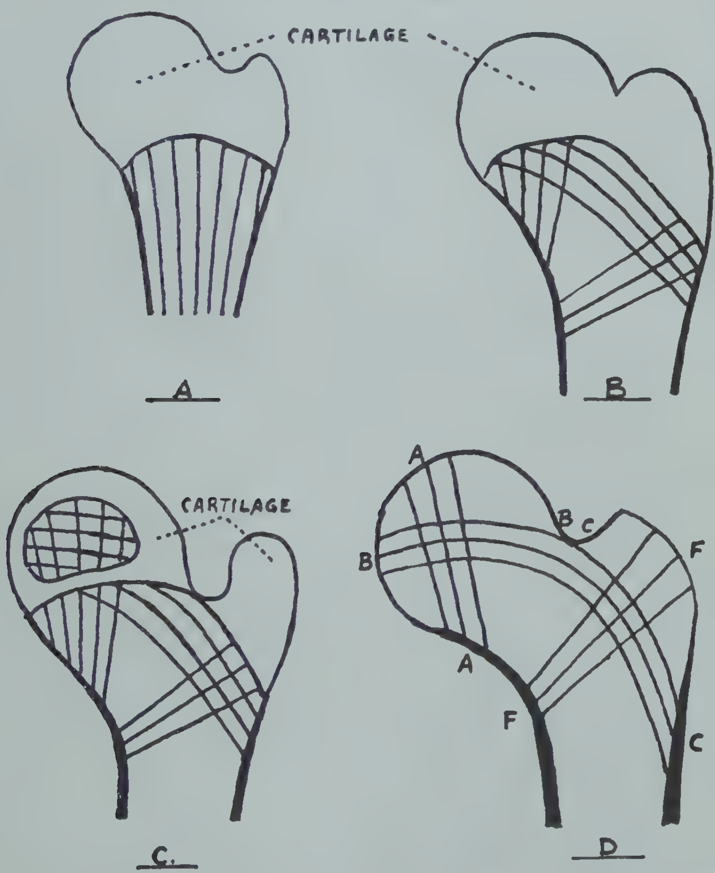

Fig. 1 Drawing of coronal sections of human femora to show the arrangement of trabeculae of bone at the upper extremity at (a) 8 months fetal life, (b) 1 year, (c) 2½ years, and (d) adult life.

remains unchanged in general form from that time onwards but is reconstructed as regards details, with the object of supporting the greater stresses imposed upon the neck by its adoption of a more horizontal position. These detailed changes include a thickening of the compacta on the medial aspect of the neck and an increase in the number and strength of the transecting trabeculated plates to prevent collapse of the tube at its curved part.

The secondary bone center appears in the head at or shortly after the end of the first year and as it enlarges it shows a pattern of transecting trabeculae which develop on the plan already adopted by the adjacent part of the neck, and so it harmonizes with the developing architecture of that region. The lines of the trabeculae in the enlarging epiphysis correspond to those in that region of the neck with which the epiphysis becomes confluent (fig. 1). The epiphysial pattern defines the future crossed-braced system of the head.

Following the appearance of the epiphysis about the age of 1 year, its architecture becomes gradually more defined and at 2½ years the vertical trabeculae (which withstand greater pressure forces) are heavier and stronger than the horizontal trabeculae (fig. 10). At 4 years of age when the epiphysial mass of bone is much larger, the adult pattern is clearly established (fig. 11).

The cross-braced arrangement of trabeculae in the head of the adult bone provides a mechanically sound structure which resists the pressure forces directed at it from various angles during movements of the joint, and especially, and most consistently, from above. This trestle-like, pressure-resisting architecture is evident in all sections — horizontal, coronal and sagittal. The superficial compact bone of the head is supported therefore by trabeculae which transmit pressure forces directly along their long axes to the whole circumference of the tube (neck of femur) on which the head is supported. Those trabeculae (A.A. in fig. 1) which pass downwards from the upper surface of the head to the under surface of the neck are stronger because they bear more

weight. The more horizontal group (B.B. in fig. 1) as part of the trestle-like structure, also withstands compression forces, mainly due to muscle contraction, and is therefore also pressure-resisting.

The upper lateral border of the neck is represented by the group of trabeculated plates (C.C. in fig. 1) and is therefore part of the tube (femoral shaft plus neck) which, although slightly curved, supports the head and is pressure bearing.

This group (C.C.) together with the horizontal group (B.B.) in the head are both pressure bearing. They are not, as the trajectorialists believed, one long curved tension resisting group (Townsley, '44). Carey ('29) and Jansen ('20) suggested that the tract on the lateral side of the neck was pressure-resisting and represented "back pressure vectors" of muscle pull.

The internal support against any tendency to collapse at the curvature of the neck region is provided for by the group F.F. (fig. 1) of pressure resisting trabeculae which transects the group of trabeculae C.C. on the lateral border of the neck. This intersection produces the cross-braced system which is established in the upper extremity of the human femur at the age of 12 months.

DETAILED DESCRIPTION OF THE ARRANGEMENT OF THE BONY TRABECULAE

Although the lines of the bony trabeculae have been described as being approximately parallel, there is actually a slight divergence or fanning-out of the lines at the end of the structure; this obliquity of trabeculae is also visible in the compact tissue of the shaft and it was described (Fell, '25) as a radiation of bone trabeculae from the center of the diaphysis. Figure 2 is a drawing of the trabeculae of bone in the compact tissue of the shaft at $4\frac{1}{2}$ months of fetal life as seen under the low-power microscope. It will be noted that connections occur between adjacent longitudinal bars in this compact tissue — but these connections are not usually distinct horizontal bars — they are for the most part, termina-

tions of slightly oblique trabeculae in the sides of adjacent trabeculae.

The explanation of the obliquity of the trabeculae both in the compact bone and in the extremity of the diaphysis may be that as the mass of cartilage (which preforms the femur) grows, it expands towards both ends and therefore the longitudinally disposed lines of bone which are laid down within the cartilage (endochondral bone) and on the surface of the cartilage (ectochondral or periosteal bone) are obliged to follow this expansion. Although the subperiosteal bony trabeculae lie for the most part in lines which are somewhat oblique in relation to the periosteum (as seen in longitudinal section, fig. 2) they were originally parallel to that membrane, but as a result of growth and enlargement of the whole structure — and especially of the ends — the periosteum in these growing bones came to lie in a continually changing relationship to the trabeculae. This change is demonstrated by the slight obliquity or tangential disposition of the older trabeculae to the overlying periosteum.

This detailed description, however, does not detract from the generalization that in the proximal end of the fetal and early postnatal femora the bony trabeculae lie in approximately parallel, longitudinal lines and that only during the first year of life do they begin to intersect in 2 groups — in the neck region and in the head of the femur. Triepel ('22) in his interpretation of the architecture of the upper end of the adult femur as a system of "domes and calyces" noted that the adult pattern was not present until 1¼ years after birth.

The following statements may be made regarding the appearance of the mechanically sound architecture during the first year:

(a) In the individual the appearance of the adult type of architecture follows the imposition of new forces on the femur due to weight bearing, walking and increased muscle contraction.

(b) The diaphysial bone has not grown sufficiently far into the angulated cartilaginous neck to require or permit the

formation of a cross-braced osseous system before the middle or end of the first year.

The elongation and curvature of the neck represent a mechanical arrangement developed on the phylogenetic scale in response to other evolutionary changes such as rotation and adduction of the limbs between reptiles and mammals and —

Fig. 2 Drawing of bony trabeculae as seen in longitudinal section of human femur at 4½ months fetal life.

in the higher forms — change in the mode of progression from quadrupedal to bipedal locomotion. In man, the pelvis has become broader, the femora inclined more medially and the neck elongated. The appearance of the relatively long angulated neck and cross-braced systems of cancellous bone in response to mechanical requirements is late both in phylogeny and ontogeny.

The phylogenetic development of the bony architecture of the femur will next be considered.

Amphibia

In the frog *(Rana temporaria)* the femur is an almost straight cylinder of bone, the cortex being slightly thinner and somewhat expanded at both extremities. The spherical head is not bony, but is formed of cartilage which surrounds the bony tube. There is no curvature in the proximal end or "neck" region and the internal architecture at this point is of simple structure designed to resist (a) forces acting along the long axis of the tube and (b) smaller forces acting at right angles to the thinned cortex in this region. The pat-

Fig. 3 Drawing of trabeculae of proximal end of amphibian (frog) femur.

tern of the architecture suggests simple bone trabeculae radiating from a central point in the proximal end of the shaft, the longitudinal trabeculae being stronger than the lateral trabeculae (see figs. 3 and 14). Glücksmann ('38) obtained a similar pattern when he subjected endosteal cultures from chick embryos to pressure between explanted ribs in vitro.

There is no naked eye evidence of trochanters and no x-ray evidence of separate epiphyses for muscular insertions. X-ray examination shows a faint transverse striation near the proximal extremity and another less definite one near the distal end, which are apparently the lines of union of terminal cartilaginous epiphyses.

Reptilia

In reptiles (e.g., iguana) the femur projects laterally in a horizontal plane from the body. It is an almost straight tube,

with a slight curvature in the proximal (neck) region; the concavity of this slight curvature faces dorsally, that is, it is opposite in direction to that of the mammalian femur, and is of smaller degree. There is a large trochanter on the inferior (medial) aspect of the bone near the head, and an indistinct button-like protuberance immediately anterior to the large trochanter. The head is bony, expanded, and flattened from above downwards and the articular surface is an elongated oval. The distal end of the femur shows slight torsion or rotation in an anterior direction.

X-ray examination of the femur of iguana shows that the internal architecture of the bony head has evolved considerably from that of the amphibia — there is a system of intersecting trabeculae (trestle-like arrangement) based on mechanical principles. These trabeculae and trabeculated

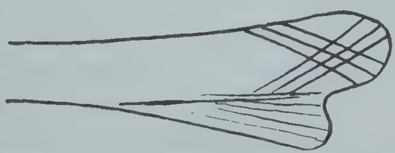

Fig. 4 Drawing of proximal end of reptilian (iguana) femur.

plates transmit pressure forces from all parts of the head to the circumference of the proximal part of the shaft. There is no second intersecting system in the neck region, such as is found in the long curved neck of the human femur, because the necessity for it does not arise in iguana. The neck of the iguana femur is only slightly bent and the direction of the long axis of the shaft of the bone is horizontal, not vertical; these features do not require the type of internal strengthening which is necessary in the neck region of the primate femur (see figs. 4 and 15).

The basic tube-like nature of the femur in lizards is evident on x-ray examination. A thickening of the trabeculae under the large trochanter defines the continuation of the shaft deep to that structure; the trochanter represents a pulling out of some of the trabeculae of bone which forms the compact tissue of the shaft and subsequently a secondary epiphysial center

appeared. Epiphysial scars are visible at the upper and lower extremities of the femur.

The trabeculae within the trochanter are pulled upon by the attached muscles and lie in the direction of traction; they are made rigid by the presence of secondary small transverse trabeculae. The larger protuberance on the medial (inferior) aspect of the bone is the greater trochanter: when rotation and adduction of the femur occurred (between reptiles and mammals) this great trochanter was carried postero-laterally into the mammalian position, and this was associated with changes in the pelvis and a more dorsal attachment of the chief muscles.

The lesser trochanter of the iguana femur was at the same time rotated from its antero-medial position to a postero-medial position — that is, into the position of the lesser trochanter of mammals. The muscles attached to these trochanters have also changed as regards their action and direction of traction. It is probable that the ilio-psoas muscle in man (a flexor muscle attached to the postero-medial lesser trochanter) was in iguana a protractor muscle attached to the antero-medial lesser trochanter.

In the case of the great trochanter (on the medial aspect of the femur) in iguana, the muscles attached there were adductors (for raising the animal from the sprawling position for faster locomotion) and retractors of the limb (for forward propulsion). By a process of (1) migration of the origin of the muscles and (2) of rotation of the femur, which carried their insertion (the great trochanter) laterally, these adductor and retractor muscles became extensor and abductor muscles (the gluteal muscles in the human). The great trochanter shows evidence, in its external form, of having been pulled upwards laterally and anteriorly by the gluteal muscles — so demonstrating the plasticity of bone in phylogeny.

PLASTICITY OF THE TUBE WHICH FORMS THE FEMUR

In the amphibia the femur is an almost straight tube or cylinder of bone extending laterally from the body and on a

plane parallel to the ground. Trochanters are absent and the head is mainly cartilaginous.

In reptiles, the tube is still relatively straight, but there is, a slight anterior torsion of the lower end; the head has become a bony structure with an internal supporting architecture, and tuberosities for the attachment of muscles have been pulled out from the cortex of the bone. One of them (the great trochanter) has acquired a secondary center of ossification.

Between the reptiles and the mammals a change in position of the limbs has occurred to provide a more rapid type of locomotion. The femora have changed from a horizontal to a vertical position and this has been achieved by an adduction of the limb under the body and a rotation of the femur, in an anterior direction, of 90 degrees.

There is a tendency in the reptilian femur to show a slight curvature (with its concavity dorsal) in the neck region and when rotation of the femur through 90 degrees took place, between the reptilian and mammalian stages of evolution, this dorsal concavity came to face anteriorly — it did not reach the mammalian (medial) position. To reach this medial position a rotation through 180 degrees would have been required and this could not have happened without disturbing the axis of the knee joint. The probable sequence of events was: (1) rotation of the femur through 90 degrees, then (2) a straightening of the neck, and subsequently (3) a bending of the neck region, again, so that the concavity was directed medially and downwards as in the mammals. This curvature was definite though small in lower mammals, so that the head may be described as being placed on the medial part of the upper end of the shaft. Sections and x-ray examination of the femur in lower mammals show a medial curvature of the outer part of the cortex where it lies deep to, and hidden by, the great trochanter: this medial curvature has reached its highest form in the human femur. There has occurred, therefore, on the evolutionary or phylogenetic scale, a bending and unbending of the plastic tubular shaft in order to provide the best

mechanical support for the weight of the body in its different positions.

The plastic nature of the great trochanter, and also of the lesser trochanter, is evident. The former (e.g. between iguana and man) has been pulled postero-laterally on the "neck," in addition to partly reaching its primate position by rotation of the femur. The lesser trochanter has acquired its position in man solely as the result of rotation of the femur.

The adoption of a curvature in the neck region of the femur required a system of internal pressure resisting struts to prevent collapse of the bent tube at its angle. These pressure-resisting struts or trabeculae, which extend from the concave to the convex border of the tube at its angle, transect the trabeculae or trabeculated plates which represent a continuation of the lateral part of the shaft deep to the great trochanter (fig. 1, D, also fig. 13), and produce on an antero-posterior radiograph the appearance of the second cross-braced system in the neck region of the mammalian femur; it is best seen in the primate femur.

It is also visible in avian femora — where the bird has a femur with a curved neck and vertical shaft resembling that of mammals. Figure 16 is an antero-posterior radiograph of the femur of *Gallus domesticus*, the common hen, and it is evident that there are 2 cross-braced systems of trabeculae — one in the head and one in the neck.

Mammalia

In the mammals the tubular nature of the shaft is still evident despite the curvature of the shaft in the neck region and the superposition of trochanters.

In quadrupeds (e.g. ox) the neck is short and the curvative of its lateral border hidden under the great trochanter. It might almost be said that the head was placed on the supero-medial part of the shaft. The shortness and small curvature of the proximal end of the shaft (neck region) demand fewer internal pressure-resisting trabeculae and trabeculated plates than in the primates, where the neck is relatively long and

more curved and requires internal support to prevent its collapse. The cross-braced system in the head is well-defined in quadrupeds.

In order to provide good mechanical leverage, the point of attachment of the muscles to the great trochanter requires to be removed some distance from the femoral head. This distance has been maintained in different ways. In the ox, where the head is closely applied to the upper medial part of the slightly curved tube, the great trochanter has been carried far laterally and projects well beyond the upper lateral part of the shaft. In the human femur, the greater trochanter is more closely applied to the upper lateral part of the shaft, while the greater curvature of the neck carries the head far medially, and thus maintains the necessary distance.

In the baboon, a primate, the lower half of the femoral shaft is almost vertical, while the upper half is curved laterally and a plumb line from the center of the head falls through the medial border of the medial condyle. The neck has a low index of ellipticity, that is, the vertical diameter is much greater than the antero-posterior diameter. The great trochanter is still relatively large and projects above the level of the head, but it represents a higher evolutionary form than that of the ox. The increased curvature of the neck has made necessary internal support in the neck region and a group of pressure resisting trabeculae and trabeculated plates (group F.F. in fig. 5) is seen to extend from the medial aspect of the base of the neck upwards and laterally to the convex part of the neck and to the great trochanter. The head is still at a lower level on the extremity of the neck than it is in the human.

Figures 5 and 17 show that the head is supported by the 2 sets of intersecting trabeculae A.A. and B.B., each of which is pressure resisting. The group C.C. of trabeculated laminae represents the upward continuation of the shaft and is also pressure resisting.

In the ox the 2 groups C.C. and B.B. are quite distinct; in the baboon they are coming into line but an angle still exists

between them; in the human they form a continuous curve because of the elevation of the head on the neck. They are, however, still 2 developmentally separate groups of trabeculated plates — each pressure resisting.

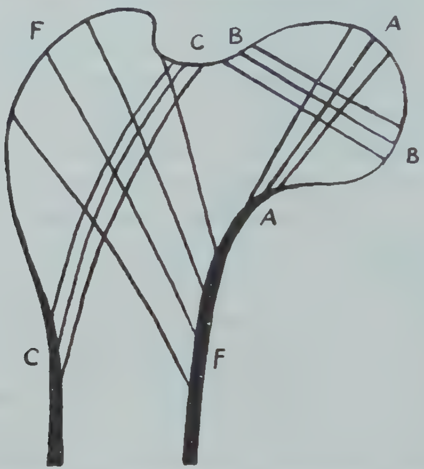

Fig. 5 Drawing of proximal end of mammalian (baboon) femur.

SUMMARY

In this paper an attempt has been made to show that Wolff's Law holds good for the arrangement of bone substance at each stage in the changing, evolving structure of the femur throughout the vertebrate kingdom, and in the growing human femur in which the mechanically efficient architecture appears at the age at which weight-bearing and walking begin. This law also applies to bone growth associated with pathological conditions (Townsley, '44, '46).

It has been shown elsewhere (a) that removal of the gluteal muscles in an immature mammal (that is, before ossific centers have appeared) does not prevent the subsequent appearance of a great trochanter, (b) that a representation of a femur will develop from the mesenchyme of a chick limb bud cultivated in vitro. Some authorities claim that these experiments disprove Wolff's Law and state that the intrinsic growth pattern theory is all important. It must be remembered, how-

ever, that strains and stresses have been applied to the femora of the ancestors of the particular chick or animal involved, and the result has been an architectural evolution, on mechanical principles, throughout phylogenetic development. The mechanically determined structures now present themselves as hereditary features in the individual, young, growing femur which has been protected experimentally from the stresses and strains of muscle pull and weight bearing.

I wish to thank the following gentlemen who have helped me and offered valuable advice: Prof. Thomas Walmsley of Queen's University, Belfast; Mr. R. M. Leman of the Radiographic Department, Royal Victoria Hospital, Belfast.

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PLATE 1

EXPLANATION OF FIGURES

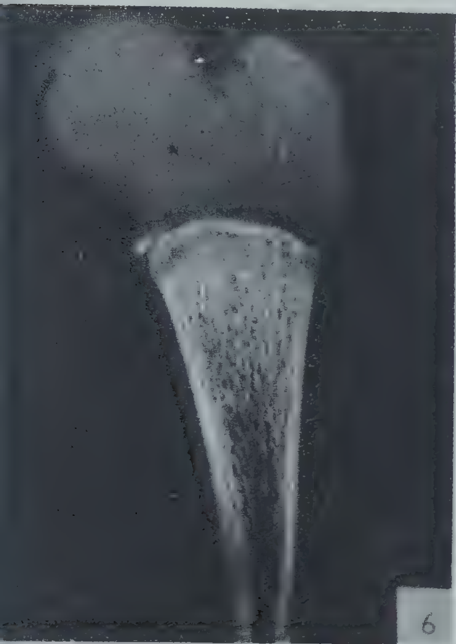
Radiographs of proximal ends of human femora.

6 At 5 months fetal life.

7 At 1 month after birth.

8 At 1 year.

9 At $1\frac{1}{4}$ years. Epiphysis for head has appeared.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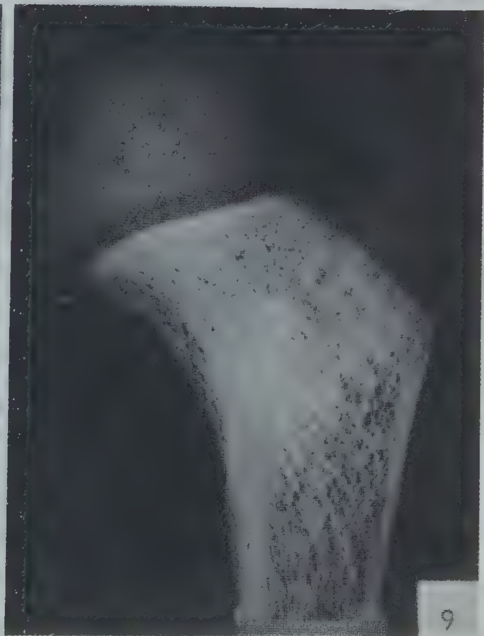
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PLATE 2

EXPLANATION OF FIGURES

Radiographs of proximal ends of human femora.

10 At $2\frac{1}{2}$ years.
11 At 4 years.
12 At 8 years.
13 At adult stage.


10
11
12
13

PLATE 3

EXPLANATION OF FIGURES

Radiographs of proximal ends of femora.

14 Of frog.
15 Of iguana; upper view is lateral, middle and lower, antero-posterior.
16 Of hen.
17 Of baboon.

14

15

16

17

Time Lag in Nutritional Benefit.— An over-all analysis has been made of the trend of dental caries in about 800,000 children surveyed by various workers in 11 European countries during the last 50 years. Following drastic reductions in consumption of refined carbohydrates at the beginning of the 2 World Wars, a marked caries reduction can be demonstrated. But the time relationship between the decrease in sugar consumption and the reduction in caries cannot be explained on the basis of a rapid mechanism in the oral environment. There is a delay of several years in the initial effect and a lag of many years in the terminal "effect of the Wars" upon the caries reduction. This time factor can best be explained by an accumulative favorable effect before the teeth erupted into the oral environment . . .

The hypothesis of an accumulative depletion of a nutritional factor or combination of factors favorable to the developing teeth is being tested.— Reidar F. Sognnaes. A possible role of food purification in the etiology of dental caries. Science, vol. 106, no. 2758, November 7, 1947, pp. 447–448.

Climatic Fluctuations and the Fossil Record.— The mammalian fauna of the present day differs only in detail from that which has prevailed throughout the greater part of the Pleistocene. However, the whole epoch has been marked by extensive migrations of both plants and animals, including man. Well-trod paths of migration have included the isthmus connecting the 2 Americas and the narrow strait that today separates North America from Asia. The prime cause of the repeated migrations can not have been other than the shifting of the climatic belts as the climates slowly fluctuated from glacial to interglacial and back again. These migrations were but one of several responses to the broad irregular fluctuations of climate. As the climate grew cold and then warm the ice sheets formed, expanded, and then shrank away, areas of the earth's crust beneath them were pushed down and then recovered, and the level of the sea was drawn down and then rose. Thus man played his small part in a vast synchronous series of actions and reactions in which the atmosphere, the sea, and the earth's solid crust responded each in its own majestic way.— Richard Foster Flint. Glacial Geology and the Pleistocene epoch. John Wiley and Sons, Inc., N. Y., xviii + 589 pp. and 6 plates, 1947. ($6.00)

GENETIC VARIABILITY WITHIN A STUDENT POPULATION

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Populations remain in equilibrium from generation to generation where mating is completely at random. This principle affords the basis upon which the student of human heredity uses gene frequency analysis in the determination of modes of inheritance. It should be noted, however, that the maintenance of equilibrium depends upon 2 conditions; first, that the population is large, and second, that mating occurs at random. The second condition is dependent upon the first. Mating cannot occur at random over long periods of time in small populations, as inbreeding inevitably will result. As long as all inbred lines are maintained, gene frequencies will not be altered, but will be masked by alteration of phenotype frequencies. But if the population remains small, all possible inbred lines cannot be continued, with the result that gene frequencies will be altered.

Even in large populations, however, mating need not occur at random among the population as a whole. Differences in religion, pigmentation, language, national origin, social-economic status and degree of education result in assortative mating among people living in the same city or geographical area. It is possible that different segments of a population may be large enough for random mating to occur within each. Although each of these segments may approach equilibrium, their respective gene frequencies may differ significantly. Religious differences have served as highly effective barriers to random mating among peoples living in the same geographical area, very likely more so in the past than in modern times.

Over long periods of time, followers of a particular religious faith may become widely scattered, and some intermixture may occur with the natives of the territories to which they migrate. Thus after a time, these various branches may differ considerably from each other. We find Jews, Moslems, and Christians in most parts of the world and among most major racial groups. That is to say that religion, national origin and geographical area do not operate independently. For instance, Spanish Jews, Spanish Catholics and Russian Jews are at least partially isolated from each other from the standpoint of reproduction. It is probable that these populations differ in the frequencies of some genetic traits. It seems almost superfluous to add that obstacles to random mating have no *direct* effect on genes, but what they can do is to reduce the size of breeding populations which in turn results in random drift in gene frequencies.

During the past 4 years various genetic and anthropometric data have been obtained from students taking the elementary course in heredity and racial groups at Ohio State University (Rife and Shonfeld, '44). These include blood groups, M and N types, Rh antigen, taste reaction to phenyl-thiocarbimide, functional handedness, finger and palmar prints and pain thresholds. The students also filled in questionnaires concerning religion and national origin of their ancestors. These data are being assembled for 2 purposes; first, to acquaint the students with the various techniques, and second, to determine how various segments of our population compare with each other in respect to the frequencies of genetic traits. Are there actually any differences in gene frequencies between portions of our population classed as Jews, Catholics and Protestants and how do the American Negroes differ from these portions of our white population? This paper is concerned with an analysis of the data pertaining to blood antigens, taste reactions, handedness, dermatoglyphics, and hair color.

Data from approximately 1850 persons are included in this report, although the total numbers vary considerably from trait to trait. The numbers tested for the Rh antigen are low

because it was not feasible to test large classes. Hair samples were not collected during the first 2 years, which accounts for the relatively small numbers tested. Tests for blood groups and types were not given to the first class, and in a few instances no samples were obtained or the test results were inconclusive. The most extensive data are those having to do with dermatoglyphics and functional handedness, although here, too, the numbers vary somewhat, due to amputations, illegible prints or failure to record information on handedness.

We attempted to place all persons tested into categories according to national origin of ancestors and religion. Considerable difficulty was encountered in the former, as many or most were of mixed origin and several did not know their ancestry. As nearly as we can determine, 90 to 95% of the total population is of northern or central European extraction. Of the remainder, 43 are Negroes, 18 Italians, 16 Greek and a few from various parts of the world.

Religion proved to be a much more satisfactory basis for classification than national origin for most of the group. Practically all knew the former and were not reluctant to state it. Those of central or northwest European, or of British ancestry were placed in the following categories: Protestants, Jews, and Catholics. There are over twice as many Protestants as Jews and Catholics combined, and about twice as many Jews as Catholics. Negroes were placed in a separate category and the remainder classed as miscellaneous, as the numbers were too small to warrant further division.

The Protestants, for the most part, are descended from British, Scandanavian and German stock. The Jewish group is predominantly of Russian, Austrian, Roumanian, or Polish descent. The Roman Catholics are mostly of Irish and German descent. All of the Negroes are Protestants, while Greeks are Greek Orthodox. Only one Jew, and none of the Protestants are of southern European extraction. Most of the miscellaneous class are Roman Catholics but are certainly of somewhat different ethnic composition from Irish and German Catholics. In view of these considerations, we have compared 4 groups:

Protestants, Catholics, Jews and Negroes. The Catholic group does not include those from Southern Europe. We hope eventually to further subdivide the first 3 groups, but numbers of individuals are as yet insufficient to allow valid comparisons. It would be desirable to know how various other groupings compare; as for example, Irish and German Catholics; Irish Catholics and Irish Protestants; Russian Jews and Russian non-Jews; German Jews, Protestants, and Catholics; Russian Jews and Spanish Jews; Greeks and Italians. The present paper may be considered a progress report of a project which we plan to continue and expand over a period of years. Data from the miscellaneous group are included in the tables, but on account of the ethnic heterogenity of the source, are not compared statistically or discussed at length.

BLOOD GROUPS

Table 1 shows the blood group comparisons. The Protestants and Catholics are quite similar. The Jews show a significantly higher frequency of gene a^B than do either the Protestants or the Catholics. Gene A occurs with approximately the same frequency in all 3 populations. Antigen B occurs more frequently among the Jews than among the Protestants or the Catholics, whereas the incidence of antigen A is very much the same in all 3 populations. Although comparatively small, the Negro population differs significantly from the others in having a lower frequency of gene A and a correspondingly higher incidence of gene a^B. This closely parallels the findings of Landsteiner and Levine (Boyd, '39). Males were also compared with females, and as might be expected, no differences of any significance were encountered.

M AND N AGGLUTINOGENS

No significant differences are shown between any of the populations in the incidences of the M and N blood types (table 2). With the exception of the miscellaneous population, gene M occurs a little more frequently than gene m in all.

TABLE 1

A. Incidence of blood groups in student populations.

POPULATION	NO. OF PERSONS	GROUP O	GROUP A	GROUP B	GROUP AB	GENE FREQUENCIES		
						p	q	r
		%	%	%	%			
Protestant	1060	45.28	40.47	11.12	3.11	.254	.056	.672
Jewish	330	35.45	40.30	15.75	8.48	.276	.120	.595
Catholic	160	46.87	38.75	10.00	4.33	.238	.070	.684
Negro	38	50.00	21.00	23.68	5.26	.138	.140	.706
Miscellaneous	66	45.45	34.84	15.15	4.54	.221	.103	.674
Male	727	43.43	39.00	11.62	4.56			
Female	927	43.27	39.58	12.58	4.55			
All groups	1654	43.34	39.33	12.15	4.55	.252	.074	.660

B. Chi-square values of differences between populations.

Antigen A	Protestants vs. Jews	2.85	Antigen B	Protestants vs. Jews	20.33 [2]
	Protestants vs. Catholics	0.00		Protestants vs. Catholics	0.00
	Protestants vs. Negroes	4.43 [1]		Protestants vs. Negroes	8.94 [2]
	Jews vs. Catholics	1.41		Jews vs. Catholics	5.17 [1]
	Jews vs. Negroes	5.20 [1]		Jews vs. Negroes	0.46
	Catholics vs. Negroes	3.61		Catholics vs. Negroes	4.59 [1]

[1] Significant.

[2] Highly significant.

TABLE 2

A. Incidence of M and N blood types in student populations.

POPULATION	NO. OF PERSONS	TYPE M	TYPE N	TYPE MN	GENE FREQUENCIES	
					p	q
		%	%	%		
Protestant	875	32.68	20.45	46.45	.559	.437
Jewish	267	30.82	22.47	46.68	.536	.453
Catholic	128	31.20	17.18	51.56	.570	.430
Negro	37	29.73	27.02	43.23	.513	.486
Miscellaneous	57	22.22	23.80	53.90	.490	.506
Males	603	31.50	21.06	47.44		
Females	761	32.19	20.23	47.30		
All groups	1364	31.89	20.60	47.36	.555	.445

B. Chi-square values of differences between populations.

Antigen M	Protestants vs. Jews	2.93	Antigen N	Protestants vs. Jews	0.06
	Protestants vs. Catholics	0.74		Protestants vs. Catholics	0.10
	Protestants vs. Negroes	0.93		Protestants vs. Negroes	0.00
	Jews vs. Catholics	0.04		Jews vs. Catholics	0.01
	Jews vs. Negroes	2.67		Jews vs. Negroes	0.06
	Catholics vs. Negroes	1.79		Catholics vs. Negroes	0.03

The Protestants show 3 to 4% more of type N and less of MN than do the Catholics, but even here the differences are not statistically significant. The similarities between the White and the Negro populations are in close agreement with the findings of other investigators (Wiener, '43). Here, too, males and females appear to have the same frequencies.

Rh ANTIGEN

The percentages of the various populations possessing the Rh antigen present the most striking similarities encountered in any of the data (table 3). No differences of consequence are shown or even indicated between the Protestants, the Catholics, and the Jews, or between the sexes. It should be kept in mind that the numbers tested are relatively small and that the tests were made only for the presence versus the absence of any Rh antigen. Tests were not made for all of the Rh subtypes. In view of the findings of various investigators (Wiener, Unger and Sohn, '45) it seems highly improbable that all of the genes in the Rh series occur in identical frequencies among all of the populations under consideration.

TABLE 3

Incidence of the Rh antigen among student populations.

POPULATION	NO. OF PERSONS	Rh POSITIVE	Rh NEGATIVE
		%	%
Protestant	455	84.75	15.25
Jewish	167	84.44	15.56
Catholic	59	84.75	15.25
Negro	15	80.00	20.00
Miscellaneous	32	89.66	10.34
Males	216	84.59	15.41
Females	486	84.98	15.02
All groups	728	84.76	15.24

TASTE REACTION

Ability to taste phenyl-thio-carbamide was tested by placing a few crystals of the compound on the back of the tongue with

a tooth pick. We have found this method more satisfactory than chewing treated paper, as some people who report no taste reaction to the latter can taste the crystals. Several interpopulation differences are apparent (table 4). The Catholics show the lowest and the Negroes the highest percenatges of tasters, the Protestants and the Jews being intermediate. The Jews show a higher percentage of tasters than either the Catholics or the Protestants, these being

TABLE 4

A. Incidence of tasting ability in student populations.

POPULATION	NO. OF PERSONS			TASTERS		
	Male	Female	Total	Male	Female	Total
				%	%	%
Protestant	421	555	976	71.49	79.27	76.00
Jewish	89	227	316	78.42	82.81	81.33
Catholic	85	59	144	65.88	83.05	70.15
Negro	15	22	37	80.00	100.00	94.12
Miscellaneous	23	35	58	73.90	74.28	74.19
All groups	633	898	1531	72.19	80.74	77.21

B. Chi-square values of differences between populations.

Protestants vs. Jews	7.19 [2]
Protestants vs. Catholics	2.25
Protestants vs. Negroes	6.64 [1]
Jews vs. Catholics	9.83 [2]
Jews vs. Negroes	3.17
Catholics vs. Negroes	2.25
Males vs. females	15.66 [2]

[1] Significant. [2] Highly significant.

highly significant statistically in both instances. Although suggestive, differences between the Protestants and the Catholics are statistically non-significant. The relatively high percentage of tasters among the Negroes is in keeping with the findings of others (Lee, '34, Snyder, '34). Females show higher percentages of tasters than do males in each of the groups, as well as in the total population. These differences are highly significant, and in accord with the findings of other investigators (Boyd and Boyd, '37).

HANDEDNESS

No single infallible criterion of handedness is known, and it can unquestionably be influenced by environment. There is ample biological evidence however, that genetic factors are involved (Cromwell and Rife, '42; Rife, '40), and there is reason to believe that a single pair of genes, lacking dominance, may be concerned. That is to say, one homozygous genotype results in right-handedness, the other homozygous genotype in left-handedness, heterozygous individuals being naturally ambidextrous and readily susceptible to environmental influences.

We used the following criteria for handedness: throwing, writing, sewing, shooting a marble, striking a match, bowling, whittling and use of hammer and saw. These criteria fall far short of perfection, in that it is impossible to distinguish homozygous and heterozygous individuals among the single-born, and the effects of training cannot be accurately evaluated. Inasmuch as we live in a right-handed world, we have arbitrarily classed anyone performing one or more of the test operations with the left hand as left-handed. In spite of the shortcomings of the test criteria, they were uniformly applied to all persons tested, so the results for the different populations are comparable. These are shown in table 5.

Note the higher frequencies of left-handedness among the Jews as compared with the Protestants and the Catholics. The differences between the Protestants and the Jews are statistically highly significant. The Negroes manifest the lowest frequency of all groups. Our data indicate a higher frequency of the gene for left-handedness among the Jews than among the Protestants. Males show slightly higher frequencies of left-handedness than do females.

DERMATOGLYPHICS

Table 6 shows percentages of fingers with whorls. The Jewish and miscellaneous populations have, on the average, about 10% more whorls than the other 3 populations. These

TABLE 5

A. Incidence of handedness in student populations.

POPULATION	NO. OF PERSONS	RIGHT	LEFT
		%	%
Protestant	1151	89.49	10.51
Jewish	379	84.96	15.04
Catholic	175	89.72	10.28
Negro	43	93.10	6.90
Miscellaneous	73	83.58	16.42
Male	770	87.83	12.17
Female	1051	89.27	10.73
All groups	1821	87.87	11.33

B. Chi-square values of differences between populations.

Protestants vs. Jews	7.19[1]
Protestants vs. Catholics	0.00
Protestants vs. Negroes	0.56
Jews vs. Catholics	2.31
Jews vs. Negroes	1.77
Catholics vs. Negroes	0.44
Males vs. females	3.12

[1] Significant.

TABLE 6

A. Incidence of whorls on fingers in student populations.

POPULATION	NO. OF PERSONS Male	Female	Total	THUMBS	INDEX	MIDDLE	RING	LITTLE	AVERAGE Male	Female	Total
				%	%	%	%	%			%
otestant	500	683	1183	30.63	33.93	15.52	45.10	15.64	30.69	26.46	28.27
wish	100	278	378	43.01	46.74	22.82	57.35	21.22	44.70	36.69	38.82
tholic	98	73	171	34.83	34.11	18.82	42.30	16.18	29.35	28.31	28.79
egro	19	24	43	39.02	33.72	14.11	34.11	9.30	28.08	23.52	25.94
iscellaneous	43	31	74	43.14	49.31	31.50	50.00	40.81	43.71	43.87	43.78
l groups	760	1089	1849	34.63	37.05	17.68	47.00	30.74	33.98	30.41	31.87

B. Chi-square values of differences between populations.

Jews versus all groups	83.88[1]
Males versus females	17.93[1]

[1] Highly significant.

differences are highly significant (table 6). The average incidence of whorls is much the same in the Protestants, Catholics and Negroes. Note that the distributions on individual digits vary considerably among these 3 populations. This suggests that the 3 sets of alleles postulated by Bonnevie ('31) as being responsible for finger tip patterns may occur with different frequencies among these groups. Our findings correspond closely with those of Cummins and Midlo ('26–'27) for New Orleans Jews as compared with unselected White Americans.

TABLE 7

A. Incidence of patterns on palms in student populations.
Palm patterns.

POPULATION	NO. OF PERSONS	HYPO-THENAR	THENAR/ FIRST INTER-DIGITAL	SECOND INTER-DIGITAL	THIRD INTER-DIGITAL	FOURTH INTER-DIGITAL
		%	%	%	%	%
Protestants	1168	34.75	10.28	5.18	39.67	62.38
Jews	378	35.18	11.79	8.22	47.70	66.36
Catholics	171	35.29	10.00	7.94	41.17	69.47
Negroes	43	30.23	17.44	16.27	39.53	79.07
Miscellaneous	73	32.87	13.01	12.32	47.91	60.96
All groups combined	1833	34.74	10.92	7.03	41.03	63.54

B. Chi-square values of interpopulation differences for each of the 5 areas.

Hypothenar	0.85
Thenar/first interdigital	7.29
Second interdigital	12.43 [1]
Third interdigital	16.94 [1]
Fourth interdigital	28.47 [1]

[1] Highly significant.

As has been reported previously (Cummins, '26), males surpass females in percentages of whorls.

Table 7 shows the incidence of patterns on the 5 palmar areas. Certain correlations have been shown to exist between the occurrence of patterns in the various areas (Rife, '43). A negative correlation exists between patterns in the hypothenar and thenar/first interdigital areas, and a positive correlation between patterns in the second and fourth interdigital areas.

These relationships are well borne out in the present data. Note that the Negroes show the highest incidence of patterns on the thenar/first interdigital area and the lowest of all groups on the hypothenar area, and also the highest of all groups on the second and fourth interdigital areas. The Catholics have higher pattern frequencies on the second and fourth interdigital areas than do the Protestants, while the Jews have higher pattern frequencies in the third interdigital areas than do either the Protestants or the Catholics. Protestants are characterized by the lowest pattern frequencies in all areas, except the hypothenar, of all the populations. The trends in the Jews and the Negroes correspond with those observed by Cummins and Midlo ('27). Multiple sets of alleles are concerned in the expression of dermatoglyphic configurations. Both on finger tips and on palms these different sets of alleles express themselves with independent frequencies in each of the populations under consideration. Positive correlations such as we have discussed appear to be due to pleiotropic genes, while negative correlations may be due to different alleles of a single series.

HAIR COLOR

Hair samples consisted of locks clipped from the scalp. These were matched against the Fischer-Saller Haarfarbentafel, the results of which are shown in table 8. The lettered classes range from A (extreme blonde) to Y (black). The series I–VI includes various shades of red, I being the lightest and VI the darkest.

Intermediate and dark brown shades are the most abundant in all populations. It is of course obvious that no hard and fast lines of distinction exist between blondes and light browns, dark browns and black, or auburn and red. We have arbitrarily classed grades A to N as light, O to Y as dark, and I to VI as red.

Dark hair occurs more frequently and light hair less frequently among Jews than among either Protestants or Catholics. Similar differences are apparent between males

TABLE 8

A. Distributions of shades of hair color in student populations as indicated by Fischer-Saller Haarfarbentafel (A to Y, graded series from light blonde to black; I–VI, shades of red).

CLASS	GRADE	PROTESTANT		CATHOLIC		JEWISH		TOTAL		
		Male	Female	Male	Female	Male	Female	Male	Female	Male + female
Light	A	0	1	0	0	0	0	0	1	1
	B	0	2	0	0	0	0	0	2	2
	C	0	0	0	0	0	0	0	0	0
	D	0	2	0	0	0	0	0	2	2
	E	0	3	0	1	0	0	0	4	4
	F	0	3	2	0	0	0	2	3	5
	G	1	0	0	0	0	0	1	0	1
	H	4	8	0	2	0	2	4	12	16
	J	3	16	1	3	0	1	4	20	24
	K	3	2	0	0	0	0	3	2	5
	L	3	23	1	2	0	1	4	26	30
	M	3	9	1	0	0	1	4	10	14
	N	2	2	2	0	1	0	5	2	7
	Total	19	71	7	8	1	5	27	84	111
Dark	O	2	17	1	1	1	4	4	22	26
	P	13	3	2	1	1	3	16	7	23
	Q	8	9	4	1	0	3	12	13	25
	R	7	13	0	1	0	8	7	22	29
	S	1	15	0	2	0	7	1	24	25
	T	12	12	2	2	1	4	15	18	33
	U	10	11	5	3	2	15	17	29	46
	V	26	15	4	2	3	14	33	31	64
	W	19	4	3	4	2	11	24	19	43
	X	8	3	3	1	5	7	16	11	27
	Y	1	0	0	0	2	0	3	0	3
	Total	107	102	24	18	17	76	148	196	344
Red	I	0	2	0	0	0	0	0	2	2
	II	1	3	0	0	0	0	1	3	4
	III	0	1	1	0	0	1	1	2	5
	IV	0	1	0	0	0	0	0	1	1
	V	1	1	0	0	0	0	1	1	2
	VI	0	1	0	0	0	2	0	3	3
	Total	2	9	1	0	0	3	3	12	15
All colors combined	Grand total	128	182	32	26	18	84	178	292	470

B. Chi-square values of differences between populations.

Protestants versus Jews	24.53 [1]
Protestants versus Catholics	1.18
Jews versus Catholics	8.52 [1]
Males versus females	13.63 [1]

[1] Highly significant.

and females. Higher incidences of both blonde and dark brown or black hair are indicated among the Catholics than among the Protestants, although these differences are statistically insignificant. Higher frequencies of red hair are suggested among males, although all groups show less than 5%.

DISCUSSION

Different sets of genes appear to be responsible for variation in each of the traits under consideration, with the partial exception of dermatoglyphics in relation to functional handedness. All occur with more or less independent frequencies among the populations studied. Significant differences are found between any 2 populations in respect to one or more traits, although they may be essentially alike in others. The Protestants and the Catholics show the greatest similarities throughout, although significant differences are encountered in the frequencies of palmar patterns, and different trends are indicated in taste reaction and hair color. The Jews and the miscellaneous group show the highest and the Negroes the lowest percentages of left-handers. The incidence of whorls on fingers is very much the same among the Protestants, the Catholics and the Negroes, but is markedly higher among the Jews. In respect to blood antigens, the 3 White populations differ in only one respect, the higher frequency of gene a^B among the Jews. Dark hair occurs more frequently among the Jews than among either the Protestants or the Catholics.

An earlier report on some of this material (Rife and Schonfeld, '44) gave comparisons of Jewish and Gentile students in respect to the frequencies of the blood groups, the blood types, the Rh antigen, taste reaction for phenyl-thio-carbamide, handedness and dermatoglyphics. Eighty-four students were included in the Jewish group, and 343 in the Gentile group. The latter group is incorporated in the Protestant and Catholic populations discussed in this paper. With the exception of the M and N blood types, the trends indicated at that time have been maintained, with only minor and insignificant deviations. The Jews consistently have shown lower

frequencies of blood group 0 and higher frequencies of groups B and AB, tasting ability, left-handedness, whorls on finger tips and patterns on certain palmar areas, than have the other White populations.

Marked changes are apparent in the percentages of the M and N blood types among Jews as compared with the earlier report. The percentage of type M has dropped from 38.1 to 30.8, while the percentage of type N has increased from 9.5 to 22.4 These differences are statistically significant, although not highly so (d.f. $= 1, X^2 - 5.40$, p is between .05 and .01). It seems unlikely that these discrepancies are due to faulty techniques or errors in recording the data, as uniform and careful procedure has been followed since the beginning of the project. We should expect on the basis of chance alone that 1 out of 20 tests should give chi-square values usually considered to be significant. In view of the fact that several traits are included in these interpopulation comparisons, an occasional inconsistency is not altogether unexpected. We shall have to await the accumulation of more data, however, before we can be sure as to whether or not the Jewish students really differ from the other student populations in regard to the percentages of the M and N blood types.

The blood antigens occur with approxmiately the same frequencies in both sexes. Males differ from females in showing lower frequencies of tasters, more whorls on finger-tips and palms, and higher incidences of dark hair. Although statistically insignificant, higher frequencies of left-handedness among males are also indicated. Similar trends appear among all of the populations under consideration.

Random drift in gene frequencies is most likely responsible for the genetic variations between the Protestants, the Catholics and the Jews. In view of the antiquity of the Jewish faith, it is not surprising that more marked differences may be noted between the Jews and non-Jews than between the Protestants and the Catholics. American Negroes comprise an ethnic group of comparatively recent origin, of mixed West African and European descent. The incidence of the genetic traits

under consideration in this group is in accord with what one might predict.

SUMMARY

The frequencies of the blood group genes, the M and N blood type genes, the Rh antigen, ability to taste phenyl-thio-carbamide, whorls on fingers, patterns on palms, and various shades of hair color were observed in White students grouped according to religion, and in Negro students. Significantly inter-population differences noted are as follows:

1. Blood group gene a^B occurs more frequently and gene a less frequently among the Jews than among either the Protestants or the Catholics. The Negroes manifest a higher frequency of gene a^B and a lower frequency of gene A than do the Protestants, the Catholics or the Jews.
2. Marked differences are shown between the student populations in respect to percentages of tasters. The highest percentage occurs among the Negroes, followed in order by the Jews, the Protestants, and the Catholics.
3. Left-handedness occurs more frequently among the Jews than among the Protestants and the Negroes.
4. Whorls on fingers occur more frequently among the Jews than in any of the other student populations.
5. Patterns occur less frequently on the second and fourth interdigital areas of the palm among the Protestants than in any of the other populations.
6. The Jews are characterized by higher frequencies of dark hair than are either the Protestants or the Catholics.

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THE ORIGIN OF SYPHILIS.— In summary it may be said that it is impossible to bring forward conclusive documentary evidence of the existence of syphilis in Europe before the Columbian period. It is also impossible to demonstrate from such material that syphilis was introduced by Columbus. The question of terminologic designation of the disease cannot be considered to offer any information likely to be of value in deciding the question. The strongest evidence either for or against the Columbian origin theory is based upon material remains. The data which have been collected favor the Columbian theory, but it should be remembered that the total amount of material studied is still relatively small, and there is little unanimity upon the criteria which are to be followed. It is diffiult to see what is to be attained by pursuing this controversy any farther for . . . it is obvious that medicine as a whole had no clear idea as to what syphilis might be until after the sixteenth century. Indeed, it has only been within the last half-century that a diagnosis of syphilis can be considered to have reached even a moderate degree of reliability.— Cecilia C. Mettler. History of Medicine. The Blakiston Co., Philadelphia and Toronto, 1947, xxv + 1215 pp. ($8.50).

DENTITION OF INDIAN CRANIA FROM TEXAS

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The present study is based on observations by the writer on the dentition of Indian crania from Texas. These crania were for the most part excavated by the archeologists of the University of Texas from pre- and protohistoric sites in various parts of the state.[1]

Except for rather full notes by Lux ('36) on the dentition of 24 Indian crania from central Texas and comments by the same author ('37) on teeth found in a mass burial near Waco, there have been few and merely incidental remarks on the teeth of Indian crania from Texas. The present work considers several hundred crania from various regions of the state, and as will be indicated, covers aspects of the dentition concerning which there is little comparative data.

Two kinds of dental observations are considered, first, those phenomena which are entirely or largely the consequence of the environment, namely, wear of teeth, dental caries, alveolar abscess, antemortem loss of teeth; and second, those characters which are genetically determined, namely, shovel-shape of the incisors, supernumerary teeth, congenitally missing teeth, number of molar cusps, and molar cusp pattern. The variability in occurrence of genetically determined characters in different groups of man, especially dental characters which,

[1] The study of the skeletal remains from Texas was done at and sponsored by the University of Texas, and I am grateful, first, to Dr. J. J. McAllister, Chairman of the Department of Anthropology at the University, for permission to publish these data, and second, to the Texas branch of the U. S. Works Progress Administration for financing the work. Additional acknowledgments will more appropriately appear in a subsequent paper on the skeletal remains.

except for attrition or decay, are presumably unaffected by the environment, should be of pertinent anthropological and biological interest. Indeed, Hrdlička ('20) long ago called attention to the marked divergence in the frequency of shovel-shaped incisors among various groups of man, also demonstrating that the phenomenon was of "morphological and phylogenetic significance." New data are here given on the incidence of shovel-shaped teeth in the early Indians in Texas, including observations on the deciduous teeth which usually receive little consideration in this regard. The present data on incidence of the "*Dryopithecus* pattern" in the molar teeth of man are the only statistics, so far as known to the writer, besides those first published by Hellman ('28).

Probably the genetic make-up of the individual is involved even in a condition like caries, some people having a greater inherent resistance to the disease than others (Klein, '46), yet there is much evidence that the types of foods eaten, even the kind of water imbibed, have a very considerable, perhaps decisive, effect on the prevalence of dental caries (Collins, '32; Krogman, '38; Pedersen, '38). With the state of Texas so vast in area and varied in its natural environment, it should be of special interest to note the effects of the differences in regional environment on the dentition of the early Indian groups living in these regions, whose cultures and food-patterns undoubtedly were conditioned by the diversity in natural environment. Hence the material is divided on a regional basis which also conforms roughly with the known archeological horizons of the area.[2]

First is *East Texas,* which refers to the "Caddo Area" of northeastern Texas where the archeology indicates a primarily agricultural society in existence between about 1300–1600. Second, *South Texas,* which includes the Gulf coast and the coastal plain, the people here subsisting in large measure on sea foods. Except for a few Indian crania from early Mission sites in the region, the crania from this area showed

[2] A recent work by Krieger ('46) provides a chronology for parts of the state based on the archeology of the regions.

no association with artifacts of European culture. The main Indian groups living in this region at the beginning of the historic period were the Atakapa, Karankawa, and Aranama.[3] Third is *West Texas,* in the present instance referring to the semi-arid southwest portion of the state, the crania coming from caves or rockshelters, with no indication of European contact associated with the remains. Groups first encountered in this region appear to have been the Coahuiltecan and Jumano. Fourth, *North Texas* (excluding the Panhandle region in the present instance), is an extension of the Great Plains, and crania from this region also, so far as known, showed no sign of European contact, although Krieger ('46) estimates the indigenous culture of the region to have extended from about 1350 to 1600. The peoples of the region appear to have been food-gatherers and hunters. Fifth is the plateau region of *Central Texas,* the crania from this area coming from sites indicating a prehistoric culture in which the subsistence of the peoples was also primarily dependent on food-gathering and hunting. The Tonkawa seem to have been the first met with in this region.

It would have been desirable, of course, to have had adequate series of crania from single sites of known date. This ideal, however, is seldom attained when working with early Indian skeletal material. In the present instance, the cultures represented by the archeology of the various sites extended over several centuries in time, and the skeletal remains under consideration may be those of peoples not living contemporaneously. However, the groups were of the same Indian ethnic stock, living in the same general region, and any temporal disparity among the groups, at most probably several hundred years, would seem scarcely great enough to have materially, if at all, affected morphological characters such as shovel shape of incisors and molar cusp pattern, or conditions like type and frequency of dental anomalies. As regards dental caries, the disease is much more a function of diet

[3] Sayles ('35) reviews the early historical or native groups of what is now the state of Texas.

than period of existence of the group, as already indicated, and it is to be noted in this connection that almost all of the groups under consideration apparently had no contact with Europeans or their foods.

DENTAL CONDITIONS AFFECTED BY THE ENVIRONMENT

Wear of teeth. Degree of molar wear is indicated in table 1. A major proportion of the crania (70.4%, males; 53.5%, females) manifest very considerable dental attrition (medium and pronounced), more so than, for example, Dr. Hooton's Pecos Pueblos series in which comparable tooth wear occurred

TABLE 1

Degree of wear of the molar teeth in adult Indian crania from Texas.

REGION OF TEXAS	TOTAL CRANIA	WEAR OF THE MOLAR TEETH			
		Slight	Moderate	Medium	Pronounced
	Number	*Percent*			
West	16	12.5	31.2	12.5	43.8
East	115	11.3	35.7	35.7	17.3
South	134	8.2	29.1	26.9	35.8
Central	61	3.3	19.7	36.0	41.0
North	44	...	31.8	45.5	22.7
Total					
Male	196	5.1	24.5	35.2	35.2
Female	174	10.3	36.2	29.9	23.6

in 54.7% of males, 40.6% of females.[4] Although excessive wear of the teeth (medium and pronounced) was apparently common among the Indians in all of the regions considered, appreciably more, relatively, of the Central Texas crania appear to have been affected by marked dental attrition than those from any other region. However, this difference may be due more or less to the somewhat higher average age at death

[4] Hooton's ('30) classification of dental attrition was slight, medium, pronounced, and very pronounced (p. 119), the latter 2 categories being taken as corresponding with the medium and pronounced stages, respectively, of the present study. The criteria of the classification used by the writer have been previously described (Goldstein, '32).

of the adult Indians in Central Texas, as estimated on their skeletal remains, namely, 43.0 years, as compared with 37.5 years in West Texas, the next highest, the lowest average age at death being 36.3 years for the South Texas groups. Indeed, a difference of about 7 years between average age of adult males and females in the present total series also may be a contributing factor in the higher frequency of marked dental attrition among the former.

Notes taken in the course of the dental observations repeatedly commented on the lack of extensive development of secondary dentine in the teeth affected by attrition, i.e., in many cases of extreme wear of the molars, the pulp cavity seemed to have been exposed relatively early, a considerable amount of tooth still remaining, in contrast, for example, with conditions noted in Eskimo crania in which the teeth are commonly worn to the "gum" before the pulp cavity is exposed (Goldstein, '32). Interestingly, the teeth of the Mission Indians in South Texas were very little worn, in sharp contrast to the excessive wear of the teeth in all of the other crania which represented groups having had no contact with European food-stuffs.

Caries, alveolar abscess, and antemortem loss of teeth. The prevalence of dental caries, antemortem loss of teeth, and alveolar abscess, respectively, in crania of adult individuals of the early Indian groups in Texas, is shown in table 2. It may be remarked that only cavities which seemed the result of decay, so far as the writer could judge, were considered as caries.

Taking crania with dental caries per se, the agricultural East Texas Indians seem to have been the most susceptible of all the groups, the nomadic food-gatherers and hunters of Central and North Texas the least affected. The West Texas cave-dwellers, albeit rather poorly represented numerically, seem to have suffered more from alveolar abscess and antemortem loss of teeth than the Indians from the other regions. Loss of teeth, of course, may be as much, or more, the consequence of excessive attrition and concomitant alveolar abscess

as that of caries, and pronounced wear of the teeth did, in fact, occur relatively most frequently among the West Texas Indians. Indeed, it may be remarked that a number of the West Texas crania, representing people of about middle age according to suture closure, had all of the lower molars missing, with the supporting structure completely resorbed, the upper molars in the same skulls, however, still being in place.

Relatively fewer of the Indians in Texas appear to have suffered from caries than did the Pecos Pueblos (males, 45.8%; females, 49.6%); significantly, only the East Texas

TABLE 2

Incidence of adult Indian crania from Texas with dental caries, antemortem loss of teeth, and alveolar abscess.

REGION OF TEXAS	PERCENT OF CRANIA (BOTH SEXES) WITH:				TOTAL NUMBER OF CRANIA
	Dental caries	Ante-mortem loss of teeth	Caries and/or ante-mortem loss of teeth	Alveolar abscess	
East	46.8	55.6	74.2	27.4	124
South	34.5	34.5	59.0	23.0	139
West	31.6	73.7	84.2	36.8	19
North	22.2	35.6	46.7	26.7	45
Central	21.2	42.4	57.6	31.8	66
Total males	32.5	45.7	62.3	30.7	212
females	37.0	43.1	64.6	22.7	181

groups, similar to the Pueblos in depending largely on an agricultural economy, approach the latter in frequency of individuals with dental decay (46.8%). Two examples of recent conditions among the American Indian may be cited. Steggerda and Hill ('36) found 50% of the Navajo and 72% of the Maya, each group 30–35 years of age, with dental caries, and Krogman ('38) noted as many as 91.7% of male full-blood Seminoles affected by the disease.[5]

The incidence of individuals with alveolar abscess also was lower in the Texas groups (indicated in table 2) than among

[5] Krogman ('38) provides an excellent statistical summary and discussion of dental caries in various peoples of the world during the course of time.

the Pecos Pueblos (males, 50.7%; females, 36.9%). As regards sex differences, the females in the Texas series, as among the Pecos Pueblos, appear somewhat more prone to dental caries than the males, but less so in the occurrence of alveolar abscess.

Condition of the dentition in relation to age is indicated in table 3. The incidence of caries rises very sharply between infancy (2–6 years) and early childhood (7–12 years), namely, 1.9% to 28.9%. Antemortem loss of teeth in the present series occurs only after about 17 years of age, and probably was a

TABLE 3

Dental caries, antemortem loss of teeth, and alveolar abscess in Indian crania from Texas, by age.

	APPROXIMATE AGE IN YEARS					
	2–6	7–12	13–17	18–34	35–54	55 +
Total crania (both sexes)	53	45	23	140	168	85
Percent of crania with:						
Dental caries	1.9	28.9	39.1	40.7	33.3	27.1
Antemortem loss of teeth	..	...	...	18.6	46.4	83.5
Caries and/or antemortem loss of teeth	1.9	28.9	39.1	50.7	60.1	90.6
Alevolar abscess	..	4.4	4.3	6.4	32.1	50.6

relatively rare occurrence in childhood. It is of interest that Rihan ('30), commenting on the Pecos Pueblos in this connection, states, "No premature loss of deciduous teeth was observed" (p. 370). Alevolar abscess and antemortem loss of teeth in the Texas Indian groups, according to the data, were obviously concomitant with the aging of the individual, as they are more or less even at the present time.

DENTAL CONDITIONS OF GENETIC ORIGIN

Shovel-shaped incisors. All of the Texas Indian crania with permanent incisors in which the character could be ascertained, manifested some degree of the lingual rim and fossa or shovel-shape in the upper front teeth (table 4). Hrdlička ('20) appears to have been the first to point out that the shovel

form of the upper incisors was a feature peculiar to Mongoloid peoples. Table 5, based largely on the material given by Hrdlička ('20, p. 452) demonstrates how sharply the Whites and American Negroes differ from peoples of definite or

TABLE 4

Incidence of shovel-shaped upper incisors in Indian crania from Texas.

	TOTAL CRANIA	SHOVEL-SHAPE			
		Absent	Slight	Moderate	Pro-nounced
	No.	*Percent*			
Crania with permanent incisors					
Male	25	...	4.0	40.0	56.0
Female	33	...	3.0	60.6	36.4
Both sexes [1]	124	...	4.8	40.3	54.8
Crania with deciduous incisors					
Both sexes	23	21.7	39.1	34.8	4.3

[1] Including crania of undetermined sex.

TABLE 5

Incidence of individuals with shovel-shaped upper incisors in several human groups (both sexes).

	NUMBER OF INDIVIDUALS	PERCENTAGE WITH SHOVEL-SHAPED INCISORS			AUTHOR
		Moderate-pro-nounced	Trace	Absent	
Sioux Indian	116	98.3	1.7	...	Hrdlička, '31
Japanese	172	95.9	1.2	2.9	Hrdlička, '20
Early Indian, Texas	124	95.1	4.9	...	Goldstein
Chinese	651	86.9	7.7	5.4	Hrdlička, '20
Indian (Pecos Pueblos)	124	86.3	...	13.7	Hooton, '30
Hawaiian	59	77.9	15.3	6.8	Hrdlička, '20
American Negro	807	10.3	49.3	40.4	Hrdlička, '20
American White	1000	5.8	42.7	51.5	Hrdlička, '20

Note: Hrdlička's ('20) categories of semi-shovel-shaped and shovel-shaped are taken to correspond with the present moderate and pronounced rubrics, respectively; his ''miscellaneous'' grouping apparently refers to individuals with at least a trace of the shovel form in one incisor and is therefore included under the ''trace'' or slight shovel-shaped incisor heading. Dr. Hooton's classification ('30, p. 121) of sub medium and medium are taken to mean that shovel form was definitely present and hence are included in the moderate and pronounced category.

partial Mongoloid stock. As regards the Negroes, the somewhat higher incidence of individuals with shovel-shaped incisors as compared with the American Whites may be due to admixture of American Indian in the former, not an uncommon occurrence among the American Negro. Additional data on groups of Whites and Negroes in this and other countries are needed to check the degree of variability in occurrence of the character in these peoples. But much more necessary would seem to be some knowledge of the mode of inheritance of the shovel form of the tooth, a matter concerning which, so far as known, there is nothing in print. Information regarding mode of transmitting the character seems an essential prerequisite to understanding the distribution of the phenomenon in different ethnic groups.

Interestingly, and apparently little remarked in the literature, the shovel form of the upper incisors even in a group of the Mongoloid stock, is much less common in the deciduous teeth than in the permanent, as indicated in table 4. Hrdlička ('20) examined 35 deciduous upper incisors in 17 American Indian skulls, finding 60% with only a "plain trace" of the lingual rim and fossa feature, and 40% with not even a trace of the shovel form, although in 41 deciduous lower incisors of the same crania, 5% of the teeth did manifest a moderate ("semi-shovel") shovel shape. The writer knows of no other comparable data on the deciduous dentition. The explanation for the rather marked divergence in morphology of deciduous and permanent incisors in the same people, is not clear.

Several crania with shovel-shaped canines were noted in the Texas series, and it is of interest that Hrdlička ('20) commented in this regard that "reduced or masked, it (lingual rim and fossa) is also common to the canines" (p. 459).

Congenital absence of third molars. The incidence of adult crania with one or more of the third molars congenitally missing is indicated in table 6. Only those crania were counted which had at least the molar regions of the upper and lower jaws preserved. It is seen that one or more third molars are missing in 18.1% of the males and 21.5% of the females.

The lower third molar is missing more frequently than the upper third molar, an observation noted in other groups also (Pedersen, '39). Hellman ('28) found 13% of the mandibles of American Indians with congenitally missing third molars, a figure much like the 14.3% of the mandibles with missing third molars among the Texas Indian groups. American Whites, according to Hellman ('36), show congenitally missing third molars in 21.7% of males and 30.8% of females, somewhat higher figures than noted among the early Indian groups living in Texas. Indeed, it is of interest to note that even among early Indian groups there was a wide range of

TABLE 6

Congenitally missing third molars in adult Indian crania from Texas.

SEX	CRANIA WITH THIRD MOLAR MISSING								TOTAL CRANIA
	Upper M3		Lower M3		Upper & lower M3		Upper and/ or lower M3		
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*Number*
Male	5	5.3	11	11.7	1	1.1	17	18.1	94
Female	4	5.1	10	12.7	3	3.7	17	21.5	79
Total	9	5.2	21	12.0	4	2.3	34	19.5	173

variation in frequency of individuals with congenitally missing third molars, since only 8.5% of the males and 3.7% of the females at Pecos Pueblo, according to Hooton ('30, p. 119), showed suppression of the third molar.

Other dental anomalies. The dental anomalies in the permanent dentition other than congenitally missing third molars are enumerated in table 7. The incisor was the only tooth other than the third molar congenitally missing in the present series of Indian crania. It may be noted that congenitally missing lateral incisors, according to Hrdlička ('21), occurred in some 3% of white Americans, a relatively much higher incidence than the 0.6% in the Texas Indian crania.[6]

[6] Reference may be made to Montagu ('40) for an extensive discussion and bibliography of the subject of congenitally missing upper lateral incisors.

There seems to have been some doubt that the lower lateral incisors were congenitally missing in any group (Schultz, '34, p. 627). That it is a relatively rare occurrence there can be no doubt. Leigh ('25, p. 193) illustrates a case of suppression of mandibular lateral incisors in a series of 400 American Indian crania, a relatively much lower incidence than the 1.7% found in the present Texas crania. Pedersen ('39, pp. 106–107) lists at least 2 of 1118 Greenland Eskimo crania as showing congenitally missing lower lateral incisors in the permanent dentition, also illustrating a case of missing lower lateral incisor in a modern Dane (p. 109); Ohashi and Tonihara reported to Pedersen that as many as 3.6% of the lower lateral incisors were congenitally missing in recent Japanese in Formosa; and the work of Dolder is cited as reporting 1.1% of 10,000 children from Switzerland with congenitally missing lower lateral incisors (Pedersen, '39, p. 110).

TABLE 7

Congenitally missing incisors, impacted teeth, and supernumerary teeth, respectively, in the permanent dentition of 177 Indian crania from Texas (both sexes).

	CRANIA WITH CONGENITALLY MISSING INCISORS				CRANIA WITH IMPACTED TEETH					CRANIA WITH SUPERNUMERARY TEETH			
	L1	L2	U2	Total	LI1 LI2	UI1	UC	LM3	Total	UI1	UI2	LI2 LPm.2	Total
Number	2	3	1	6	1	4	2	1	8	2	1	1	4
Percent	1.1	1.7	0.6	3.4	0.6	2.2	1.1	0.6	4.5	1.1	0.6	0.6	2.2

Note: L = lower jaw; U = upper jaw; I = incisor; C = canine; Pm. = premolar.

So far as the writer knows, there is no information as to whether suppression of the lower lateral incisor is genetic in origin. To be sure, the tooth germ of the lateral incisor could be injured occasionally and not develop, and the rarity of the phenomenon would seem to support this possibility. Such accidents might indeed occur, but the fact that the incidence of missing lower lateral incisors is no less than that of the upper lateral incisors in some groups (cf. Montagu, '40), and since the heritability of the latter has been repeatedly demon-

strated, it would seem the probability of a genetic explanation for suppression of the lower lateral incisors cannot be excluded.

As regards impaction of teeth, both genetic and environmental factors may be involved. A jaw too small to accommodate the dentition could be the result of an inherent or genetic cause, or of a disturbance in growth due to sundry environmental reasons. In any event, not many of the Indians in the Texas region apparently had impacted teeth, although when it did occur, the impaction was often extreme, e.g., canines and incisors high in the maxilla or deep in the mandible. Some 6.0% of the females, as compared with 3.3% of the males, had impacted teeth.

The relative frequency of crania with supernumerary teeth, 2.2% among the Texas Indian groups, is quite similar to that noted in the Pecos Pueblos, 1.6% (Hooton, '30, p. 121); supernumerary teeth were observed in 0.9% of "white North Americans" according to Stafne (cited by Pedersen, '39, p. 102).

Not tabulated yet perhaps worth mentioning are instances of several crania exhibiting fused deciduous lower central incisors (Rihan, '30, p. 371, cited a Pecos Pueblo child of about 2 years of age with the lower central and lateral incisor fused); pointed or cone-shaped deciduous canines; a diastema 5 mm in width in the permanent dentition, between the lateral incisor and canine in the maxilla, on both sides; the lingulum of the upper incisors reaching the incisal edge (Hrdlička, '20, p. 173, remarks, "A single strong lingual cusp may in extreme cases, in an incisor, reach near or to the cutting edge of the tooth and give the same a form approaching that of a bicuspid").

Molar cusps in upper jaw. The upper M1-M2-M3 cusp formulae are given in table 8. It is clear that the Indian groups in Texas were much like the Pecos Pueblos in number of cusps in the upper molar teeth, the primary formulae in each being 4-4-3, 4-3-3, and 4-4-4, the first and second formula

each occurring in some 30% and the last in about 20% of the crania in both groups.

Since a greater number of single teeth were available than maxillae having all 3 molars in place, a count of cusps was made on single upper molars, indicated in table 9. The upper first molar of the Indians in Texas is definitely four-cusped; the second molar is more variable than the first, generally,

TABLE 8

Upper molar (M1-M2-M3) cusp number formulae in Indian crania from Texas, compared with formulae of Pecos Pueblos (both sexes).

	NO. OF CRANIA	UPPER MOLAR (M1-M2-M3) CUSP NUMBER FORMULAE										
		4-4-6	4-4-5	4-5-4	4-4-4	4-4-3	4-3-5	4-3-4	4-3-3	4-4-2	4-3-2	4-4-1
		Percent										
Texas Indians	96	2.0	1.0	1.0	19.8	30.2	1.0	7.2	30.3	3.1	4.2	..
Pecos Pueblos[1]	92	..	1.0	..	14.1	31.5	..	1.1	29.3	8.7	13.0	1.1

[1] From Hooton, '30.

TABLE 9

Number of cusps in maxillary molar teeth of Texas Indian groups (both sexes).

TOOTH	NUMBER OF TEETH	NUMBER OF CUSPS				
		6	5	4	3	2
		Percent				
Permanent						
M1	270	0.4	..	99.6	...	...
M2	228	..	1.2	59.3	39.4	...
M3	158	1.2	3.7	36.7	53.8	4.4
Deciduous						
M1	61	..	..	3.3	9.8	86.9
M2	80	..	..	98.8	1.2	...

however, having 4 or 3 cusps, somewhat more frequently the former; the third molar is the most variable tooth, but also most commonly has 3 or 4 cusps, more often the first number. The noted progression in variability of number of cusps from first to second to third molar also occurs in the lower jaw, and in fact, according to the data of de Terra ('05), is a phenomenon common to all varieties of man, as is a virtually completely stable condition of 4 cusps in the maxillary first molar.

Data on the deciduous molars, not frequently given in the literature, indicate that 2 cusps generally occur in the upper first molar, and 4 cusps nearly always in the second. The deciduous second molars, lower as well as upper, as will be indicated below, appear to be virtually identical as the permanent first molar in number of cusps and, in the lower teeth, in cusp pattern. The explanation for this striking similarity is not clear.

Cusps in molar teeth of lower jaw. Number of cusps and the cusp pattern in the lower molar teeth of the Texas Indian groups are compared with corresponding original data on Alaska Eskimo.[7] The method of determining cusp pattern is simple and has been fully explained and illustrated in the works of Gregory and Hellman ('26) and Hellman ('28). In brief, the buccal cusps, from front to back, are designated as 1 and 3, and the lingual cusps, also front to back, as 2 and 4, each being more or less separated, of course, by the transverse and longitudinal grooves. When cusps 1 and 4 are in contact in the center, often preventing cusps 3 and 2 from meeting, it is called the cruciform or plus shaped pattern; when there is contact in the center between cusps 3 and 2 and none between 1 and 4, it is considered the Y or *Dryopithecus* pattern.

According to Gregory and Hellman in the studies cited, the Y pattern, especially when associated with 5 cusps, is the typical "*Dryopithecus* pattern" of the lower molars, while the cruciform (+) pattern, particularly when concurrent with a reduction in number of cusps, is a progressive stage in lower molar crown evolution.

The present data, given in table 10, indicate that in the permanent dentition it is only the first molar which is predominantly of the *Dryopithecus* Y pattern, generally with 5

[7] Thanks to the generous permission of Dr. A. Hrdlička while he was alive, and Dr. T. D. Stewart, present Curator of the Division of Physical Anthropology in the U. S. National Museum, observations made by the writer a number of years ago on the large collections of Eskimo crania in the Division, may be incorporated for comparative purposes in the present study.

cusps; this is evident in both ethnic groups, although much more accentuated in the Eskimo. The second and third molars, especially the former, are most commonly cruciform in pattern, both in the Texas Indian groups and in the Eskimo.

Hellman ('28, pp. 170–171) has also presented data on cusp pattern in the lower molars of Eskimo and American Indians. Of 29 first molars in the former, 28 had the Y 5 pattern, as did all of 97 first molars of the Indians, in each instance a

TABLE 10

Cusp numbers and pattern of lower molar teeth in Texas Indian and Alaska Eskimo crania.

		TEXAS INDIANS				ALASKA ESKIMO		
		Permanent molars M1	M2	M3	Decid. M2	Permanent molars M1	M2	M3
Number of teeth		160	206	91	74	67	132	59
Percent of teeth with:								
	Y 7	...	...	...	1.4	...	...	...
	+ 7	0.6	...	...	...	...	...	...
Total	7	0.6	...	...	1.4	...	...	...
	Y 6	8.1	...	4.4	9.5	6.0	3.0	6.8
	+ 6	3.1	2.4	8.8	1.4	1.5	21.3	18.6
Total	6	11.2	2.4	13.2	10.9	7.5	24.3	25.4
	Y 5	60.6	1.5	7.7	68.9	83.6	9.8	13.6
	+ 5	26.9	23.8	38.5	18.9	4.5	42.5	50.9
Total	5	87.5	25.3	46.2	87.8	88.1	52.3	64.5
	Y 4	0.6	3.4	6.6	...	1.5	3.0	...
	+ 4	...	68.9	34.1	...	3.0	20.5	10.2
Total	4	0.6	72.3	40.7	...	4.5	23.5	10.2

substantially higher incidence than found in the present series. In 30 Eskimo lower M 2's, the Y 5 and Y 4 pattern occurred 6 and 7%, and only one of 99 lower second molars of the Indians had a Y pattern (with 5 cusps). Finally, of 29 third molars of the Eskimo, none, according to Hellman, exhibited the Y pattern, and 5% of 84 third molars of the Indians had the Y 4, none the Y 5, pattern. The present

series of lower second and third molars of Indians and Eskimo manifest a relatively much higher frequency of the *Dryopithecus* Y pattern, especially in the third molar, than found by Hellman, the divergence perhaps being due to variability of the character in subgroups of the same stock.

It may be noted that the incidence of lower second molars with 4 cusps in the Texas Indian groups is rather high for the American Indian (72.3%), although the quadritubercular pattern of the lower M 2 among the latter is not "relatively rare" as Sullivan ('20, p. 256) seemed to think (e.g., 54.1% in Pecos Pueblos — Hooton, '30). Differences in molar cusp numbers and patterns among various groups of Indians, as well as among peoples of other races, are probably due to inadequate samples, or when the samples are adequate, to actual variability in subgroups as a result of secular factors such as greater isolation and inbreeding in one group than another.

Cusp number and pattern of the lower deciduous second molar is also given in table 10. In both respects it is strikingly like the permanent first molar, with a high prevalence of the Y pattern and 5 cusps, in fact, not one of the present series of deciduous teeth showing less than 5 cusps.[8]

Mention perhaps should be made that not infrequently in the present series 6 cusps actually referred to 4 ordinary and 2 definitely smaller or "half" cusps, the hypoconulid usually being divided into 2 smaller cusps; similarly, 7 cusps could refer to 5 ordinary and 2 smaller cusps. This distinction in size of cusps occurs in the upper molars as well as in the lower, although never in the upper first molar, at least not in the present series.

DISCUSSION

Several dental characters considered primarily genetic in origin have been discussed with reference to relative frequency in American Indian and other groups. It should be

[8] It should be noted for the record that table 13, p. 233, in Goldstein, '31, seems to be in error; the data could not possibly pertain to the lower dedicuous *first* molar. There is no reason to doubt the validity of the other data in the aforementioned paper.

noted in this connection that a character considered to be of genetic origin is one which may be attributed to the gene-chromosome mechanism, transmitted from parents to offspring. Clearly not all heritable characters can be equated alike, and the variability in relative frequency of such characters might give a clue as to their biological history and significance. That is, besides the genetics of the family, there is a genetics of the group or tribe, a genetics of the larger group or race, and a genetics of the species, each of these various aspects of genetics in man being correlated with more or less distinctive environmental influences which profoundly affect the variability of heritable characters in the group. Dobzhansky ('41) has called attention to the fact that "A population may be said to possess a definite genetic constitution, which is evidently a function of the constitutions of the individuals composing the group" (p. 11), and farther, "The influence of selection, migration, and geographical isolation . . . mold the genetic structure of populations into new shapes, in conformity with the secular environment and the ecology, especially the breeding habits of the species" (p. 14). Only by such a concept, it would seem, could one account for the fact that some characters of genetic origin are common to all groups of man, others appear in markedly divergent proportions in different races of man, and still other traits occur in different relative frequencies within the same race or between families of the same group.

Examples illustrating the above will be confined to the data on the dentition given in the preceding, although others could be cited. The old *Dryopithecus* Y pattern of the molar teeth typical of fossil primates and the living anthropoids has become, so far as known, a cruciform pattern in the lower second molar of most individuals in all groups of recent man (Gregory, '34, p. 229; Hellman, '28, p. 168). In other words, the genetics of this heritable character, definitely in the lower second molar and tending thereto in the lower third molar, seems to have encompassed the species, in conjunction, it may

be added, with a general reduction in number of cusps (the hypoconulid), especially in the second molar.

The shovel form of the upper incisors, in sharp contrast, appears definitely and preponderantly linked with Mongoloid peoples, or with groups in which there has been miscegenation with Mongoloid peoples, as in the case of the Hawaiians. It is of interest in this connection that the shovel form of the upper incisors is already perceived in the *Sinanthropus* (Weidenreich, '46, p. 84). Hrdlička ('20) felt the development of the shovel form (koilomorphy) was in response to an original need for strengthening the front teeth, a hypothesis which, in his opinion, explained why "cultured white man and in such former relatively highly cultured branches of the white race as the Egyptians, the shovel-shaped feature . . . has so largely disappeared. The teeth of these strains have unquestionably in general suffered weakening, due to less use. The great frequency of the condition in the present yellow-brown peoples, may on the other hand probably be explained not so much by the greater call upon the teeth in these races as by a hereditary persistence from earlier times, together possibly with the play of selection" (p. 465).

How much more "cultured" the various groups of the "white" man once were or are today than the "colored" peoples, is a rather moot point. Of more direct concern is the assumption that use or disuse, even with a dash of selection, can be the cause of a genetic change such as the virtual elimination of the shovel form of the incisors in 2 of the great races of man. Such an hypothesis seems to the writer essentially Lamarckian, and is not an uncommon view expressed or implied as an explanation for changes in morphological traits of a genetic character (e.g., Sullivan, '20, p. 255; Montagu, '40, p. 328). Even when selection is brought into the picture to explain what otherwise would seem like Lamarckism, there is usually little or no discussion, let alone evidence, on just how selection could have brought about the phenomenon in question, especially pertinent as regards traits that are widely disseminated in one or more populations, e.g., shovel-

shaped incisors, molar cusp pattern, loss of diastemata. The actual mode of inheritance of the shovel form of the incisor, it may be mentioned, seems to be quite unknown (Gates, '46, p. 370). Of especial interest is that this feature is an example of a genetic character peculiar for the most part to a great race of man, which nevertheless has been modified by the environment in the sense of variation in its relative frequency, apparently as a result of migration, miscegenation, social customs, geographical isolation, and probably other secular factors.

Finally there are heritable traits occurring in varying frequencies in local groups of the same race. Congenital absence of the third molars is a case in point, occurring in all groups of man, and yet varying considerably as between local groups (e.g., 1.3%, 9.0%, 19.7%, 30.8%, in as many different White groups — Pedersen, '39, p. 122). Probably the degenerate or missing incisor teeth, and even the occurrence of supernumerary teeth, could be considered in this category. These latter phenomena in fact occur so relatively infrequently in any group (highest incidence of individuals with missing upper lateral incisors, 3.2% in whites; highest incidence with degenerate or missing upper lateral incisors, 7.8% in Chinese — adapted from Hrdlička by Montagu, '40, p. 338), that the genetics involved would seem necessarily confined to particular family lines. The incidence of missing incisors therefore could be greater among families of the the same group than between 2 or more different groups.

Environmental factors such as geographical or social isolation and consequent inbreeding, social customs conducive to outbreeding, and the like, must bear most directly and profoundly on the genetics of the local group. This process would seem to be applicable today in "civilized" societies in which the local group has generally become enlarged, as well as, and probably in much greater force, to "primitive" societies, past and present. It is recognized, of course, that the genetics of the local group is part of that of the larger population or race. All that is being suggested is that there are genetic

traits more peculiar to local groups than to the larger population as a whole, and that the relative frequency and even kind of genetic traits is in each instance most influenced by specific environmental factors indigenous to the local group.

SUMMARY

Data on the dentition of early Indian crania from Texas are presented, including observations on (a) the primarily environmental conditions of attrition, caries, alveolar abscess, and antemortem loss of teeth; and (b), the primarily genetic phenomena of shovel shape of incisors, supernumerary teeth, congenitally missing teeth, number of cusps and the cusp pattern in the molar teeth.

Marked attrition was found to be common in the Texas Indians, except in Mission Indians who probably shared in European foodstuffs. Caries was most prevalent in the agricultural East Texas Indians, least prevalent in the nomadic food-gatherers and hunters of Central and North Texas. The West Texas cave-dwellers suffered most from alveolar abscess and antemortem loss of teeth, probably more as a result of marked attrition of the dentition than of caries. Regarding age, caries and antemortem loss of teeth seemed relatively rare in childhood among these Indians. In fact, antemortem loss of teeth and alveolar abscess both appeared a concomitant of increasing age after about 35 years.

The shovel-shaped incisor occurred in all of 124 crania with the permanent dentition, 95% of these manifesting a well-defined degree of shovel shape; the feature was found to be much less common in the deciduous dentition. Congenitally missing third molars occurred in 19.5% of the crania, relatively more in the lower than in the upper jaw. Only 4.5% of the crania had impacted teeth; 3.4% had congenitally missing incisors; 2.2% had supernumerary teeth. The primary M1-M2-M3 cusp formulae in the upper jaw were 4-4-3 (30%), 4-3-3 (30%), and 4-4-4 (20%). Data on deciduous upper molars showed 2 cusps generally in M1 and 4 cusps nearly always in M2. Data on number and pattern of cusps in the lower

molars are given for Eskimo as well as the Texas Indians. In the permanent dentition only the M1 is predominantly of the *Dryopithecus* Y pattern, generally with 5 cusps; the M2 and M3, especially the former, is each most commonly cruciform in pattern; 5 cusps (or more) occur much more frequently in the M2 and M3 of the Eskimo than in those of the Texas Indians.

A discussion of the results attempts to evaluate the meaning of different types of relative frequencies of morphological hereditary features; it is noted that some are common to the species, others seem to have racial significance, and still others reflect conditions in local tribes or groups. It has been suggested that the environment is a pervasive influence in diverse ways whatever the genetic character,[9] but also that the environment is probably most direct and potent a factor in the genetics of the local group.

It is a pleasure to acknowledge, with thanks, the many pertinent suggestions made by Dr. T. D. Stewart in the organization of the present paper, as well as a critical perusal of the paper by Dr. W. M. Krogman and its discussion by Dr. F. Weidenreich.

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[9] A pertinent passage by Dobzhansky ('41, p. 209) in this connection reads, ". . . what is inherited in a living being is not this or that morphological character, but a definite norm of reaction to environmental stimuli."

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THE SUBCLAVIAN AND AXILLARY ARTERIES IN MACACUS RHESUS, COMPARED WITH MAN

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TWENTY-NINE FIGURES

The present study of the subclavian and axillary arteries is made from dissections of these arteries in 150 specimens of Macacus rhesus. This material was received from Dr. H. A. Howe of the Johns Hopkins Medical School, and has already been used for a statistical treatment of the brachial plexus (Chase and De Garis, '40). We repeat here our thanks offered in the previous report.

Since the arterial dissections were concurrent with those of the brachial plexus, it was impossible to preserve some details of arterial distribution. Nor was any attempt made to consider the topographical divisions of subclavian and axillary arteries as defined respectively by the m. scalenus anterior and m. pectoralis minor in human anatomy. In each of the 150 specimens both right and left sides were dissected, thus affording data on symmetry in a total of 300 dissections. The question of sex of the specimens is not answerable. The course of the arteries in relation to the brachial plexus is recorded in each case, and comparisons are made between the rhesus and human patterns and courses.

PATTERNS OF THE ARTERIA SUBCLAVIA

The following branches of the a. subclavia are those usually listed as normal and of normal sequence in man: (1) a. vertebralis, (2) a. mammaria interna, (3) truncus thyreocervicalis,

(4) truncus costocervicalis. Variations in this pattern frequently result from shifting of some branches of the truncus thyreocervicalis, notably the transversa scapulae and transversa colli, to separate origins from the subclavia. Such variants often arise lateral to the anterior scalene muscle.

In rhesus the most frequent pattern of subclavian branching (type As, fig. 1) comprises the following sequence: (1) a. vertebralis, (2) a. cervicalis profunda, (3) a. intercostalis suprema, (4) a. cervicalis ascendens, (5) truncus communis for a. transversa scapulae and a. mammaria interna. There is no a. thyreoidea inferior in rhesus. Lack of inferior arterial supply to the thyroid gland is very prevalent among primates, from which circumstance it follows that there is usually no common trunk properly designated *thyreocervicalis*. This absence of the inferior thyroid artery was noted by Lineback ('33) in rhesus and by Manners-Smith ('10) and others in lower and higher primates. Thus Glidden and De Garis ('36) found the following branches of the subclavia in chimpanzee: (1) a. vertebralis, (2) a. mammaria interna, (3) a. cervicalis ascendens, (4) truncus costocervicalis; the a. transversa scapulae was a branch of the mammaria interna. Although chimpanzee has no inferior thyroid artery, its thyroid gland usually does receive an inferior blood supply by way of the a. thyreoidea ima (De Garis, '41). In rhesus, however, the thyreoidea ima occurred but twice in 153 specimens (De Garis, '38), in one instance from the carotis sinistra and in the other from the truncus communis for anonyma and carotis sinistra.

The most medial branch of the subclavia in rhesus is the a. vertebralis, which passes upward to disappear beneath the longus colli muscle. The rhesus pattern having no truncus costocervicalis, the a. intercostalis suprema and the a. cervicalis profunda arise separately from the subclavia. The cervicalis profunda is usually a small artery that lies deeply along the cervical vertebrae; the intercostalis suprema passes dorso-medially and supplies the upper 2 or 3 intercostal spaces. The cervicalis ascendens courses upward and medially to

supply superficial and deep cervical muscles. The mammaria interna arises by a common trunk with the transversa scapulae just above the first rib, takes a ventro-medial course over the apical pleura and disappears behind the sterno-clavicular joint. At this level it gives off branches to the thymus and the mediastinal pleura and then descends on the inner surface of the costal cartilages. The transversa scapulae passes laterally and somewhat ventrally to reach and cross the superior transversa scapular ligament; about midway in its course it gives off the a. cervicalis superficialis.

A statistical comparison of branching patterns in man and rhesus will follow the detailed classification of variant patterns in rhesus, which latter are computed on the basis of type As (fig. 1) as the norm or most frequent pattern, as described above. (Incidence of type As: 216 dissections, i.e., 216/300, or 72 ± 2.59%).[1]

Variants listed below are often minor rearrangements of branches already described in some detail, and therefore require no extensive explanation.

Type Bs (fig. 2). In this type the cervicalis superficialis (B) does not arise from the transversa scapulae, as in type As, but directly from the truncus communis with the mammaria interna and the transversa scapulae. (Incidence of type Bs: 26/300, or 8.6 ± 1.6%).

[1] The mean or standard error (Ea), which follows any given percentage A, is computed from the formula $Ea = \sqrt{\frac{A \times (100 - A)}{n}}$ where n is the total number of specimens. The percentage difference (P. diff.) is simply the differnce between any two percentages; the standard error of the difference (E diff.) is computed from the formula $E \text{ diff} = \sqrt{Ea^2 + Ea_1^2}$ where Ea is the standard error of one percentage, Ea_1 the standard error of the other percentage. Only when the percentage difference is greater than three times the standard error of the difference does it become likely that such a difference is statistically significant. In much of the literature on variation the probable error is employed; this is 0.6745 times the standard error, and deviations as great as four times the probable error may be due to chance. In the present work the test of signifiance as shown by the standard error of the difference in any two percentages is not computed, but the standard error for each percentage is given, from which the standard error of any selected difference may readily be found by using the second formula noted above.

Type Cs (fig. 3). The a. mammaria interna arises directly from the subclavia, not from a truncus communis with the a. transversa scapulae. (Incidence of type Cs: 24 times in 12 specimens, or $8.0 \pm 1.5\%$).

Type Ds (fig. 4). The a. cervicalis ascendens is unusually large and supplies the entire region postero-medial to the a. transversa scapulae, thus replacing a definitive a. cervicalis superficialis. (Incidence of type Ds: 9 times in 5 specimens or $3 \pm 0.98\%$).

Type Es (fig. 5). The a. thoracalis lateralis is here a branch of the subclavia where the latter crosses the first rib. This anomalous thoracic artery supplies intercostal spaces 1 to 6 inclusive. (Incidence of type Es: twice in 1 specimen or 0.66 $\pm$ 0.46%).

Type Gs (fig.6). This type shows the truncus communis for transversa scapulae and mammaria interna as being unusually long and extending downward and medially. (Incidence of type Gs; 4 times in 2 specimens or $1.33 \pm 0.66\%$).

Type Hs (fig. 7). In this type a long truncus communis for transversa scapulae and mammaria interna arises much

EXPLANATION OF FIGURES 1 TO 27

Figures 1 to 9, a. subclavia; figures 10 anl 11, variant types of the a. axillaris; figures 12 to 17, a. axillaris (medial third); figures 18 to 23, a. axillaris (lateral third); figures 24 to 27, courses of the subclavia and axillaris in relation to the brachial plexus.

A, a. transversa scapulae
B, a. cervicalis superficialis
C, a. mammaria interna
D, a. cervicalis ascendens
E, a. cervicalis profunda
F, a. vertebralis
G, aa. mediastinales et thymicae
H, a. intercostalis suprema
I, a. thoracalis lateralis
K, a. thoracoacromialis
L, truncus communis of:
    a. thoracalis lateralis
    aa. circumflexae humeri
    a. subscapularis
M, a. subscapularis
N, a. circumflexa humeri posterior
O, a. circumflexa humeri anterior
P, truncus communis of:
    a. subscapularis
    aa. circumflexae humeri
R, lateral cord (plexus brachialis)
S, posterior cord (plexus brachialis)
T, medial cord (brachial plexus)
U, n. medianus
V, n. radialis.

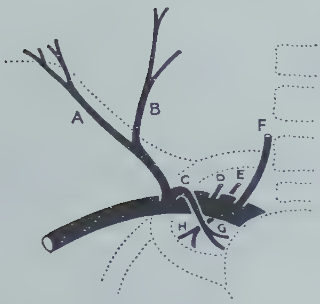

Fig. 1. *(type As)*

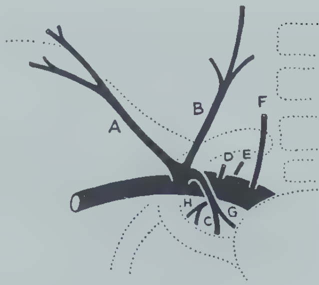

Fig. 2. *(type Bs)*

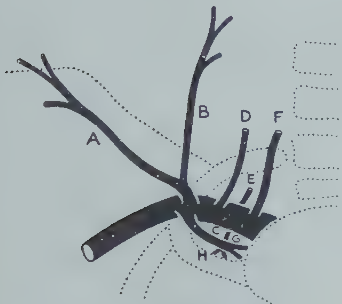

Fig. 3. *(type Cs)*

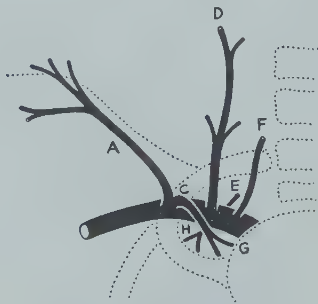

Fig. 4. *(type Ds)*

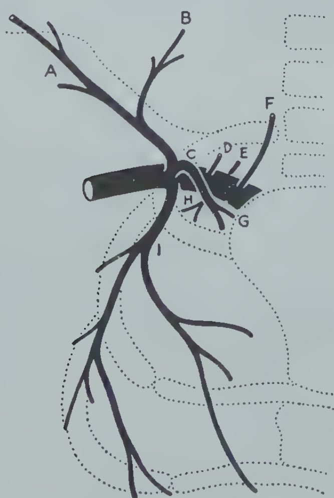

Fig. 5. *(type Es)*

more mesially than normal and takes an abrupt anterior and lateral course. (Incidence of type Hs: 4 times in 2 specimens or 1.33 ± 0.66%).

Type Is (fig. 8). Here a long truncus communis for transversa scapulae and mammaria interna arises medial to the upper border of the first rib and extends directly upward and medially. (Incidence of type Is: both sides of 1 specimen or 0.66 ± 0.46%).

Type Js (fig. 9). A truncus communis, designated J, gives origin to the mammaria interna and a trunk which passes medially upward to terminate in a long ascending and a short descending cervical branch. From this trunk are given off the transversa scapulae and cervicalis superficialis. (Incidence of type Js: both sides of 1 specimen or 0.66 ± 0.46%).

Type Ks (Fx) (fig. 10). In this type the truncus communis for transversa scapulae and mammaria interna is given off lateral to the first rib, therefore from the axillary instead of the subclavian artery. (Incidence of type Ks: 6 times in 3 specimens or 2.0 ± 0.8%).

Type Ls (Ex) (fig. 11). This is a group in which the axillary rather than the subclavian artery gives origin to the transversa scapulae and the mammaria interna as separate branches. (Incidence of type Ls: 5 times in 3 specimens or 1.6 ± 0.72%).

PATTERNS OF THE ARTERIA AXILLARIS

In the conventionally normal human a. axillaris the pattern of branching is in the following sequence: (1) a. thoracalis suprema, (2) a. thoracoacromialis, (3) a. thoracalis lateralis, (4) a. subscapularis, (5) a. circumflexa humeri anterior, (6) a. circumflexa humeri posterior. In contrast, the normal or most frequent rhesus pattern of the axillaris consists of 2 branches only, (1) a truncus communis at the level of the human a. thoracoacromialis, from which trunk arise the thoracoacromialis and the thoracalis lateralis (type Ax, fig. 12, and (2) a truncus communis at the level of the human a. subscapularis, from which trunk arise the subscapularis

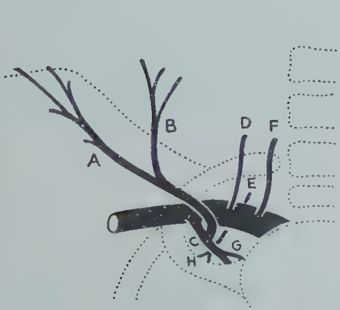

Fig. 6. *(type Gs)*

Fig. 7. *(type Hs)*

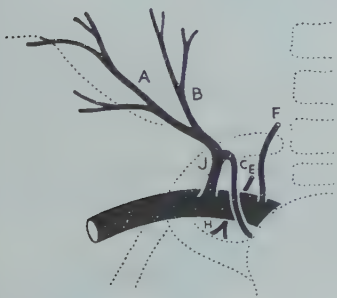

Fig. 8. *(type Is)*

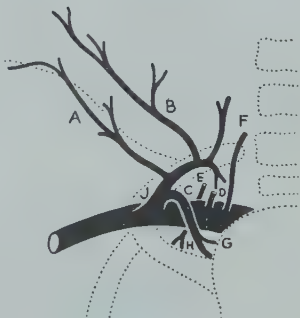

Fig. 9. *(type Js)*

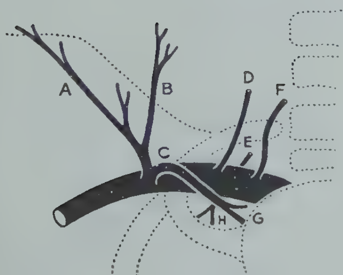

Fig. 10. *(type Ks: also type Fx)*

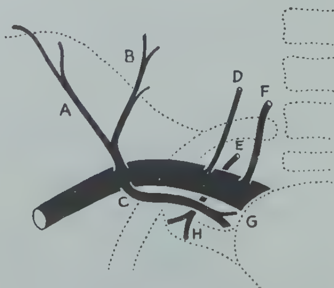

Fig. 11. *(type Ls: also type Ex)*

and a secondary trunk of origin for the 2 humeral circumflex arteries. Since in rhesus the arteries are clumped in these 2 regions, which approximate the thoracoacromial and subscapular levels in man, our statistics on the axillary artery have been compiled for each of these regions, with variants computed on the basis of 2 regional norms (type Ax, fig. 12 and type A′x, fig. 18).

THORACOACROMIAL REGION

Type Ax, (fig. 12). As stated above, the norm of axillary branching for this region consists of a truncus communis for the thoracoacromialis and the thoracalis lateralis. The ramus acromialis is similar in distribution to that in man. The thoracalis lateralis supplies intercostal spaces as far caudally as the sixth or seventh. There is no a. thoracalis suprema. (Incidence of type Ax: 143 times in 72 specimens or 47.6 ± 2.88%).

Type Bx (fig. 13). The thoracoacromialis and the thoracalis lateralis arise separately from the axillaris. (Incidence of type Bx: 82 times in 41 specimens or 27.0 ± 2.57%).

Type Cx (fig. 14). The acromialis here arises as a branch of the thoracalis lateralis. (Incidence of type Cx: 56 times in 28 specimens or 18.6 ± 2.24%).

Type Dx (fig. 15). In this type the acromalis arises from a superior ramus of the thoracalis lateralis. (Incidence of type Dx: 4 times in 2 specimens or 1.33 ± 0.66%).

Type Ex (Type Ls) (fig. 11). In this type the mammaria interna and transversa scapulae take separate origin from the axillaris, other branches in this region conforming to types As and Ax, figs. 1 and 12. (Incidence of type Ex: 5 times in 3 specimens or 1.6 ± 0.72%).

Type Fx (Type Ks) (fig. 10). The transversa scapulae and mammaria interna arise by a common trunk from the axillaris instead of the subclavia, other branches conforming to types As and Ax, figs. 1 and 12. (Incidence of type Fx: 6 times in 3 specimens or 2.0 ± 0.80%).

Type Gx (fig. 16). The thoracoacromialis of this type arises separately from the axillaris, whereas there is a truncus communis (L) giving origin to the thoracalis lateralis and a stem which terminates as the subscapularis and the aa. circumflexae humeri. (Incidence of type Gx: twice in 1 specimen or 0.66 ± 0.46%).

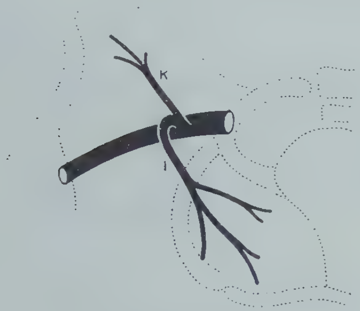

Fig. 12. *(type Ax)*

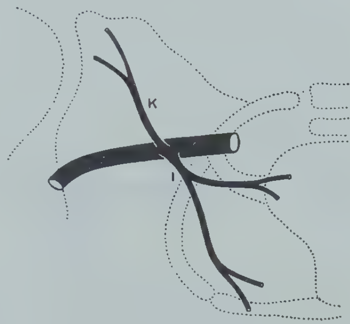

Fig. 13. *(type Bx)*

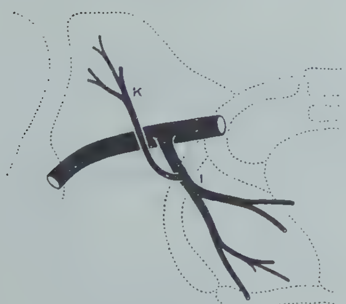

Fig. 14. *(type Cx)*

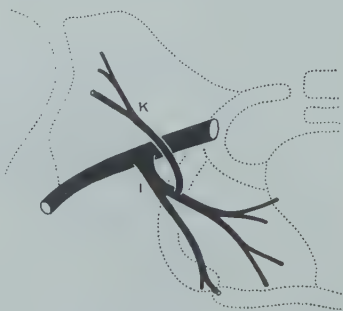

Fig. 15. *(type Dx)*

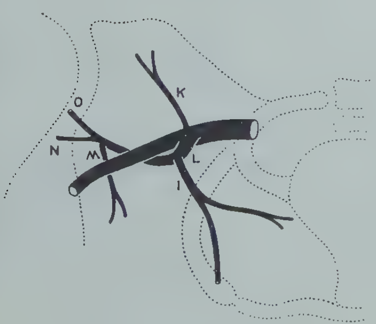

Fig. 16. *(type Gx)*

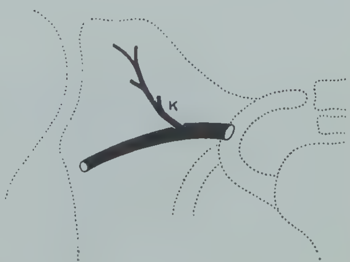

Fig. 17. *(type Hx)*

Type Hx (fig. 17). Here the axillaris gives rise only to the thoracoacromialis (K), the thoracalis lateralis coming from the subclavia (fig. 5, I). (Incidence of type Hx: twice in 1 specimen or 0.66 ± 0.46%).

SUBSCAPULAR REGION

Type A′x (fig. 18). As already stated, the axillary branches in the lower or subscapular region have a truncus communis of origin (P in fig. 18) as the normal or most frequent pattern. This trunk gives off the large a. subscapularis and terminates in the aa. circumflexae humeri anterior et posterior. (Incidence of type A′x: 257 times in 128 specimens or 85.0 ± 2.02%).

Type B′x (fig. 19). Here the circumflexa humeri anterior is a direct branch of the axillaris. A truncus communis is shared by the subscapularis and the circumflexa humeri posterior. (Incidence of type B′x: 34 times in 17 specimens or 11.3 ± 1.83%).

Type C′x (fig. 20). In this type the subscapularis takes separate origin from the axillaris; the circumflexae humeri anterior and posterior arise by a common trunk. (Incidence of type C′x: 4 times in 2 specimens or 1.33 ± 0.66%).

Type D′x (fig. 21). In this unusual type the a. thoracalis lateralis arises from the subscapular region as a separate stem. Likewise each of the arteries commonly found in this region, viz. the subscapularis and the circumflexa humeri anterior and posterior, arises separately. (Incidence of type D′x: once in 1 specimen or 0.33 ± 0.33%).

Type E′x (fig. 22). The a. profunda brachii (unlabeled) is here found as a branch of the truncus communis (P). (Incidence of type E′x: twice in 1 specimen or 0.66 ± 0.46%).

Type F′x (fig. 23). In this type each of the 3 arteries characteristic of the subscapular region, viz. the subscapularis and the circumflexae humeri anterior et posterior, arises separately from the axillaris. (Incidence of type F′x: twice in 1 specimen or 0.66 ± 0.46%).

In order to present a complete picture of the results of our observations we have compiled table 1 to show, opposite the storage number of each specimen, the type of branching in each region for right and left sides. Thus the questions of symmetry and combinations of patterns in each specimen are dealt with much more briefly and effectively than would be possible if descriptions of these combinations were attempted.

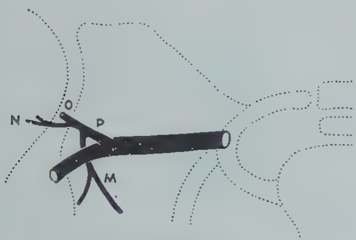

Fig. 18. *(type A'x)*

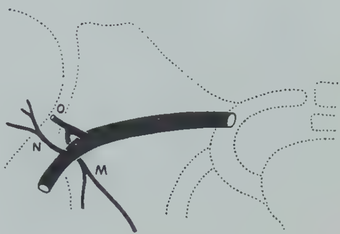

Fig. 19. *(type B'x)*

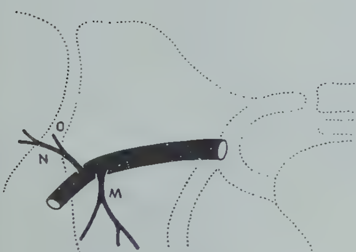

Fig. 20. *(type C'x)*

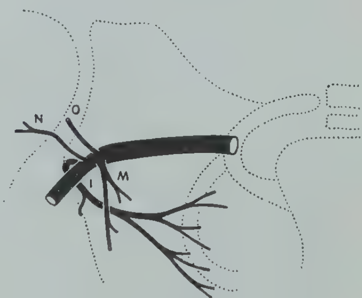

Fig. 21. *(type D'x)*

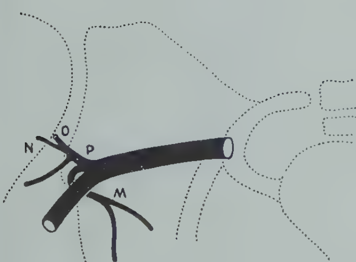

Fig. 22. *(type E'x)*

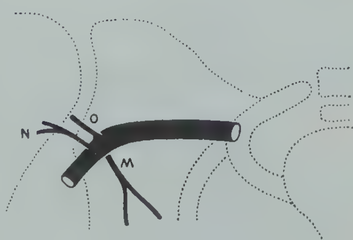

Fig. 23. *(type F'x)*

TABLE 1

The normal a. subclavia, pattern As, occurs on right and left and the a. axillaris, normal in both regions, patterns Ax and A'x, occurs on right and left in these numbered specimens: 1, 3, 5, 6, 8, 9, 12, 13, 15, 16, 17, 18, 19, 22, 26, 27, 47, 48, 51, 52, 54, 57, 63, 67, 80, 81, 98, 103, 112, 115, 125, 126, 130, 132, 138, 140, 141, 142, 147, 148. The following tabulation shows only the numbered specimens having one or more variant branching patterns (letter symbols) or diverse types of courses (numeral designations). Right and left sides are indicated respectively by letters R and L.

NO.	COURSE	PATTERNS OF SUBCLAVIA		PATTERNS OF AXILLARIS			
		Normal	Variant	Normal		Variant	
				Thoraco-acromial	Subscapular	Thoraco-acromial	Subscapular
4	1	As R–L			A'x R–L	Bx R–L	
7	1	As R–L			A'x R–L	Cx R–L	
10	1		Cs R–L		A'x R–L	Cx R–L	
11	1	As R–L			A'x R–L	Cx R–L	
14	1		Cs R–L	Ax R–L	A'x R–L		
20	1		Cs R–L	Ax R–L	A'x R–L		
21	1		Ks R–L		A'x R–L	Fx R–L	
23	1		Ds R–L	Ax R–L	A'x R–L		
24	1		Cs R–L	Ax R–L			C'x R–L
25	1	As R–L		Ax R–L			C'x R–L
28	1	As R–L		Ax R–L			F'x R–L
29	1		Ks R–L		A'x R–L	Fx R–L	
30	1		Ds R–L	Ax R–L	A'x R–L		
31	1	As R	Ds L	Ax R–L	A'x R–L		
32	1		Cs R–L	Ax R–L	A'x R–L		
33	1		Cs R–L		A'x R–L	Gx R–L	
34	1		Cs R–L	Ax R–L	A'x R–L		
35	1		Cs R–L	Ax R–L	A'x R–L		
36	1		Ds R–L	Ax R–L	A'x R–L		
37	1		Bs R–L		A'x R–L	Cx R–L	
38	1	As R–L			A'x R–L	Bx R–L	
39	1		Hs R–L		A'x R–L	Bx R–L	
40	1		Ls R–L		A'x R–L	Ex R–L	
41	1		Ks R–L		A'x R–L	Fx R–L	
42	1	As R–L			A'x R–L	Cx R–L	
43	1		Cs R–L	Ax R–L	A'x R–L		
44	1	As R–L			A'x R–L	Cx R–L	
45	1		Ds R–L		A'x R	Cx R–L	D'x L
46	3R–4L	As R–L		Ax R–L	A'x R–L		
49	1	As R	Ls L	Ax R	A'x R–L	Ex L	
50	1		Js R–L	Ax R–L	A'x R–L		
53	1	As R–L			A'x R–L	Cx R–L	
55	1	As R–L		Ax R–L			B'x R–L
56	3R–4L		Cs R–L			Cx R–L	B'x R–L
58	1	As R–L			A'x R–L	Bx R–L	
59	1	As R–L		Ax R–L			B'x R–L
60	1	As R–L				Bx R–L	B'x R–L
61	1	As R–L			A'x R–L	Cx R–L	
62	1		Bs R–L		A'x R–L	Bx R–L	
64	1	As R–L			A'x R–L	Dx R–L	
65	1	As R–L			A'x R–L	Bx R–L	
66	3R–4L	As R–L			A'x R–L	Bx R–L	
69	2	As R–L			A'x R–L	Cx R–L	

TABLE 1 (*continued*)

NO.	COURSE	PATTERNS OF SUBCLAVIA		PATTERNS OF AXILLARIS			
		Normal	Variant	Normal		Variant	
				Thoraco-acromial	Subscap-ular	Thoraco-acromial	Subscap-ular
70	1	As R–L			A′x R–L	Cx R–L	
71	1	As R–L			A′x R–L	Cx R–L	
72–76	1	As R–L			A′x R–L	Bx R–L	
77	2	As R–L			A′x R–L	Bx R–L	
78	1	As R–L			A′x R–L	Dx R–L	
79	1	As R–L		Ax R–L			B′x R–L
80	2	As R–L		Ax R–L	A′x R–L		
82	2	As R–L		Ax R–L	A′x R–L		
83	2		Cs R–L		A′x R–L	Bx R–L	
84	1		Bs R–L			Cx R–L	B′x R–L
85–88	1	As R–L				Bx R–L	B′x R–L
89	3R–1L	As R–L			A′x R–L	Bx R–L	
90–92	1	As R–L			A′x R–L	Bx R–L	
93	1		Bs R–L		A′x R–L	Bx R–L	
94–95	1	As R–L			A′x R–L	Bx R–L	
96	1	As R–L		Ax R–L			B′x R–L
97	1		Bs R–L	Ax R–L	A′x R–L		
99	2	As R–L		Ax R–L			B′x R–L
00	1	As R–L			A′x R–L	Bx R–L	
01	2	As R–L			A′x R–L	Cx R–L	
02	1	As R–L			A′x R–L	Bx R–L	
04	1	As R–L			A′x R–L	Bx R–L	
05	2	As R–L			A′x R–L	Bx R–L	
06	1		Cs R–L		A′x R–L	Bx R–L	
07	1		Bs R–L			Cx R–L	B′x R–L
08	1		Es R–L		A′x R–L	Hx R–L	
09–111	1	As R–L			A′x R–L	Cx R–L	
3	1		Bs R–L			Cx R–L	E′x R–L
4	1	As R–L			A′x R–L	Cx R–L	
6–118	1	As R–L			A′x R–L	Cx R–L	
19	2		Is R–L		A′x R–L	Bx R–L	
20	1		Bs R–L		A′x R–L	Bx R–L	
21	1	As R–L			A′x R–L	Bx R–L	
22	4		Gs R–L		A′x R–L	Bx R–L	
23	3	As R–L			A′x R–L	Bx R–L	
24	1		Bs R–L	Ax R–L	A′x R–L		
27	1	As R–L			A′x R–L	Cx R–L	
28	2		Bs R–L			Cx R–L	B′x R–L
29	3	As R–L				Bx R–L	B′x R–L
31	1	As R–L		Ax R–L			B′x R–L
33	1		Bs R–L	Ax R–L	A′x R–L		
34	2	As R–L			A′x R–L	Bx R–L	
5–136	1	As R–L			A′x R–L	Cx R–L	
7	1		Hs R–L		A′x R–L	Bx R–L	
9	1		Gs R–L	Ax R–L			B′x R–L
3	1L–4R		Ls R–L		A′x R–L	Ex R–L	
4	2	As R–L			A′x R–L	Bx R–L	
5	3R–4L	As R–L		Ax R–L	A′x R–L		
6	1	As R–L			A′x R–L	Bx R–L	
9	3		Bs R–L	Ax R–L	A′x R–L		
0	1		Bs R–L	Ax R–L	A′x R–L		

In table 2 the totals and percentages are given for the different patterns of subclavia and axillaris, in the case of the latter as to thoracoacromial and subscapular regions.

TABLE 2

Showing distribution of branching patterns of the a. subclavia and the two axes of the a. axillaris on both sides or on one side only, with total occurrence, per centum incidence and mean error of each pattern.

BRANCHING PATTERNS	OCCURRENCE ON BOTH SIDES	OCCURRENCE ON ONE SIDE ONLY	TOTAL OCCURRENCE	PER CENTUM INCIDENCE AND MEAN ERROR
		A. subclavia		
As	107	2 on right only	216	72.00 ± 2.59%
Bs	13		26	8.66 ± 1.62%
Cs	12		24	8.00 ± 1.56%
Ds	4	1 on left only	9	3.00 ± 0.98%
Es	1		2	0.66 ± 0.46%
Gs	2		4	1.33 ± 0.66%
Hs	2		4	1.33 ± 0.66%
Is	1		2	0.66 ± 0.46%
Js	1		2	0.66 ± 0.46%
Ks	3		6	2.00 ± 0.80%
Ls	2	1 on left only	5	1.66 ± 0.73%
		A. axillaris: Thoracoacromial axis		
Ax	71	1 on right only	143	47.66 ± 2.88%
Bx	41		82	27.33 ± 2.57%
Cx	28		56	18.66 ± 2.24%
Dx	2		4	1.33 ± 0.66%
Ex	2	1 on left only	5	1.66 ± 0.73%
Fx	3		6	2.00 ± 0.80%
Gx	1		2	0.66 ± 0.46%
Hx	1		2	0.66 ± 0.46%
		A. axillaris: Subscapular axis		
A′x	128	1 on right only	257	85.66 ± 2.02%
B′x	17		34	11.33 ± 1.82%
C′x	2		4	1.33 ± 0.66%
D′x		1 on left only	1	0.33 ± 0.33%
E′x	1		2	0.66 ± 0.46%
F′x	1		2	0.66 ± 0.46%

COURSES OF THE ARTERIES

In some specimens the subclavia and axillaris lie, as to their respective regions, at higher or lower levels than normal.

This is best demonstrated by considering the relations of the arteries to the brachial plexus.

Course 1 (fig. 24). Normally the subclavia lies ventral and slightly caudal to the root of the first thoracic nerve and passes laterally along the medial cord of the plexus to enter the axilla. In the axillary fossa the axillaris passes ventral to the medial head of the median nerve, then through the

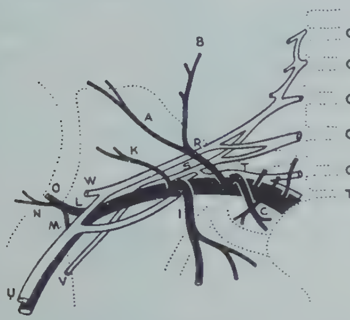

Fig.24 (course 1.)

Fig.25 (course 2)

Fig. 26 (course 3)

Fig.27 (course 4)

median nerve loop and descends posterior and medial to the median nerve. This normal relationship is found in 125 specimens on both right and left sides and twice on the left side only. (Incidence of course 1: 84.0 ± 2.52%).

Course 2 (fig. 25). In the most frequent variation both the subclavia and the axillaris pass laterally at what appears to be 1 segment lower than normal. However, in view of

previous findings in rhesus (Chase and De Garis, '40) where both pre- and post-fixed plexuses were occasionally observed, it seems highly probable that in at least some of the specimens showing course 2 the plexus is shifted cranially rather than the artery pattern being shifted caudally. (Incidence of course 2: bilateral in 30 specimens or 10.0 ± 1.73%).

Course 3 (fig. 26). The subclavia and axillaris seem to pass through their respective regions at levels higher than normal, at least as judged by their relations to the brachial plexus. Some of these cases may well be examples of post-fixed plexuses. In the subclavia having this course the truncus communis for mammaria interna and transversa scapulae

TABLE 3

Summarizing the occurrence of normal and variant courses of the subclavian-axillary artery in relation to the brachial plexus.

COURSE	OCCURRENCE ON BOTH SIDES	OCCURRENCE ONLY ON RIGHT SIDE	OCCURRENCE ONLY ON LEFT SIDE	TOTAL OCCURRENCE, PER CENTUM INCIDENCE AND STANARD ERROR	
1	125		2	252	84.00 ± 2.11%
2	15			30	10.00 ± 1.73%
3	3	5		11	3.66 ± 1.08%
4	1	1	4	7	2.33 ± 0.87%

arises more medially than usual. (Incidence of course 3: 3 times bilaterally and 5 times on the right side only, or 3.66 ± 1.07%).

Course 4 (fig. 27). The variant course taken by the arteries here is one of relationship to the plexus rather than a question of level. The arteries bear a normal relation to the lower border of the plexus but the subclavia passes through the loop formed where the anterior divisions of the lateral and posterior trunks unite to produce the lateral cord. This course is associated with an anomalous branching of the axillaris in that the thoracoacromialis and thoracalis lateralis have separate origins. (Incidence of course 4: once bilaterally, once on the right side and 4 times on the left side, or 2.33 ± 0.86%).

EXPLANATION OF FIGURES 28 and 29

A′, a. axillaris
B′, truncus communis of the following:
- a. thoracalis lateralis
- a. subscapularis
- a. circumflexa humeri anterior
- a. circumflexa humeri posterior

C′, a. brachialis superficialis
D′, a. nutricia humeri
E′, a. profunda brachii
F′, a. collateralis ulnaris superior
G′, a. collateralis ulnaris inferior
H′, n. medianus
I′, n. ulnaris
J′, fasciculus lateralis (plexus brachialis)
K′, fasciculus medialis (plexus brachialis)
L′, n. musculocutaneus

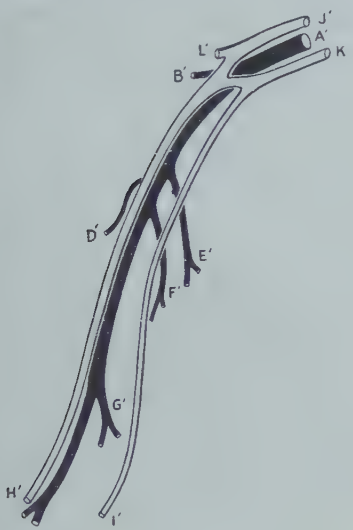

Fig. 28

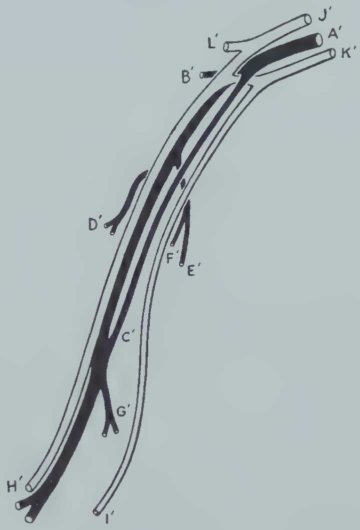

Fig. 29

Attention is called to table 1 where a column is devoted to courses of the arteries, also to table 3 which is a summary of the statistics dealing with courses.

Incidental to the present study arose the question of high origin of the a. brachialis superficialis, an artery in man occasionally found to arise from the axillaris. Our material was reviewed for such an occurrence, and a single but interesting example was uncovered. In figure 28 is shown the normal pattern of the axillaris and brachialis in relation to the median and ulnar nerves. Figure 29 depicts the 1 case in which the a. brachialis superficialis was found. This anoma-

lous artery is seen to arise from the third part of the axillaris at the loop of the median nerve. It then passes ventral to the medial limb of the loop and follows a course parallel to the larger and main a. brachialis until it reaches the lower third of the brachium. Just proximal to the origin of the a. collateralis ulnaris inferior the anomalous artery joins the brachialis, instead of continuing as one of the forearm arteries, which is its usual destination in man. This anomalous pattern clearly exemplifies a primitive arterial loop formed around the median nerve loop. It is, however, essentially a feature of the brachium, and is not included in any of our present tabulations.

COMPARING THE SUBCLAVIAN AND AXILLARY ARTERIES OF RHESUS AND MAN

A. subclavia

As previously stated, we have ignored the relations of the subclavia and axillaris to the m. scalenus anterior and m. pectoralis minor respectively. However, for purposes of comparison table 4 has been formulated on the basis of division of the arteries into medial, middle and lateral thirds with the normal branches of these divisions in rhesus and in man arranged as opposite columns.

Reference to the table shows that from the medial third of the subclavia in man are given off the vertebralis, the truncus thyreocervicalis and the mammaria interna. The same portion of the subclavia in rhesus gives off a single branch, the vertebralis. The second part of the human subclavia gives off but 1 branch, the truncus costocervicalis, whereas the same part in rhesus has 3 branches, the cervicalis profunda, the intercostalis suprema and the cervicalis ascendens. In man the third or lateral part of the subclavia conventionally gives off no branches (actually it often does supply something to the scapular region); in rhesus this third part yields a truncus communis for the transversa scapulae and mammaria interna.

In this series of rhesus monkeys 72% of the subclaviae fall within the norm, leaving a variability of 28%. In a series of 52 Whites and 87 Negroes De Garis ('24) found a subclavian variability in Whites of 40.3%, in Negroes of 75.2%. From the above figures it seems fair to say that

TABLE 4

Showing a comparison of the branches given off from topographical divisions of the subclavian and axillary arteries in man and rhesus monkey.

	Man		Rhesus
A. SUBCLAVIA			
1st part	a. vertebralis truncus thyreocervicalis: (1) a. thyreoidea inferior (2) a. transversa scapulae (3) a. tranversa colli	Med. ⅓	a. vertebralis
2nd part	truncus costocervicalis: (1) a. cervicalis profunda (2) a. intercostalis suprema	Mid. ⅓	a. cervicalis profunda a. intercostalis suprema a. cervicalis ascendens
3rd part	Conventionally no branches	Lat. ⅓	truncus communis: (1) a. mammaria interna (2) a. transversa scapulae
A. AXILLARIS			
1st part	a. thoracalis suprema	Med. ⅓	truncus communis: (1) a. thoracalis lateralis (2) a. thoracoacromialis
2nd part	a. thoracoacromialis a. thoracalis lateralis	Mid. ⅓	Usually no branches
3rd part	a. subscapularis a. circumflexa humeri ant. a. circumflexa humeri post.	Lat. ⅓	truncus communis: (1) a. subscapularis (2) a. circumflexa humeri ant. (3) a. circumflexa humeri post.

rhesus is least variable in subclavian branching, that Whites are intermediate and that Negroes are most variable.

The rhesus pattern of the subclavia differs markedly from the human norm. There is in rhesus a striking shift away from the clumping of branches on common trunks of origin, with the result that a norm of 5 or 6 branches prevails in

place of the usual number of 4 branches in man. Something of this same shift away from clumping has been observed in Negroes (De Garis, '24). In rhesus variations from the norm almost always involve the truncus communis for the transversa scapulae and mammaria interna, this trunk coming from the third part of the subclavia. The most frequent of these variants is a shifting of the cervicalis superficialis from its usual transverse scapular origin to a direct branching from the truncus communis. In man the variations of the subclavia are centered largely in 2 regions, the truncus thyreocervicalis from the medial third of the artery and the conventionally unbranched lateral third, from which various neck and scapular branches may arise as well as, on rare occasions, the mammaria interna, which latter arrangement reproduces the normal pattern in rhesus. Occasionally in man the transversa scapulae and mammaria interna share a common trunk of origin; the incidence of this arrangement is according to authors as follows: Quain (1844) 2%; Thompson (1891) 1.6%; Bean ('05) 10.1%; De Garis ('24) 1.1% in Negroes and 0.9% in Whites; Adachi ('28) 3.3% in Japanese.

Bilateral symmetry of subclavian patterns in rhesus is found in all but 2 specimens. In both of these the normal pattern occurs on the right side, an anomalous pattern on the left side. The types of anomalous branching in these 2 specimens are to be seen in figures 4 and 11. Bean ('05) found that there was a tendency for the branches of the human subclavia to arise in clumps on the left side. Our rhesus material clearly does not show this tendency.

In a comparison of the subclavia in man and rhesus 2 very constant features are worthy of note: (1) the a. thyreoidea inferior is almost always present in man, whereas it is always absent in rhesus, as in any primates other than man; (2) the a. vertebralis both in man and rhesus may vary much in size but is constanly a stem of the proximal third of the subclavia in rhesus and is the least variable branch of the subclavia in man, the conspicuous exception being the origin of the vertebralis sinistra direct from the arch of the

aorta. Such aortic origin of the vertebralis has not been found in any of our rhesus material, nor did it occur in a large series of other primates (De Garis, '41).

A. axillaris

Reference to the second part of table 4 shows that in man the medial third of the axillaris gives off the thoracalis suprema. In rhesus there is no thoracalis suprema, but a truncus communis here provides origin for the thoracoacromialis and the thoracalis lateralis. In man the middle third of the axillaris conventionally gives off the thoracoacromialis and the thoracalis lateralis, whereas in rhesus no branches come from this region. In man the lateral third of the axillaris gives off 3 separate branches, the subscapularis and the circumflexae humeri anterior and posterior. In rhesus these same 3 branches arise from the axillaris by a truncus communis (see figs. 12 and 18). It is notabe that while in man the standard pattern is that of 6 branches given off directly from the axillaris, in rhesus the normal comprises 2 common trunks of origin for the entire distribution of the axillaris.

Since there are only 2 branches (common trunks) given off directly from the axillaris in rhesus, and since the thoracoacromialis and the subscapularis are the main arterial axes from which the blood supply of the axillary region is derived, the regions of their origins are referred to respectively as the thoracoacromial and the subscapular regions. These regions are separately figured and are listed as separate headings in tables 1 and 2.

The normal combination of axillary regional branching in rhesus is type Ax (fig. 12) with type A′ (fig. 18). Variations from the normal rhesus pattern occur more frequently in the proximal than in the distal portion of the artery. In the proximal portion the patterns are 47.6% normal, in the distal portion they are 85% normal, the normal in each region being that found most frequently in rhesus for the given region. In the proximal region the most frequent variant is type Bx

(fig. 13), in which the thoracoacromialis and the thoracalis lateralis arise separately from the axillaris. In the distal region the most frequent variant is type B′x (fig. 19), where the circumflexa humeri anterior arises separately from the axillaris. P'an ('40) found that in Chinese subjects the distal portion of the axillaris is more variable, a condition which we find reversed in rhesus.

In the axillaris, as in the subclavia, bilateral symmetry prevails in all but 2 specimens; in these latter the variants occur on the left side. Adachi ('28), Trotter et al. ('30) and P'an ('40) have found that in man the left side is somewhat less variable, and for this reason more stable, than the right side. Our findings in rhesus show a trend toward greater variability on the left side, though certainly on a statistical basis our findings in this connection are not significant.

Statistical data on the arteries in rhesus have until now been entirely lacking. Manners-Smith ('10–'11) who studied the limb arteries of primates included with his own findings those of Popowaki, Bayer, Bluntschli and Müller. The result is a compilation which offers some information on the entire primate group. However, the number of specimens representing each species is not more than 2 or 3. He presents data on 5 macaques (3 Macacus radiatus, 2 Macacus rhesus), and notes that the clumping of branches of the axillaris on 2 axes is very prevalent among primates and especially among members of the family Ceropithecidae (Lasiopygidae), to which rhesus belongs.

Lineback ('33) describes the arteries of rhesus monkey but does not state the number of specimens examined. In his illustration of the subclavian-axillary pattern (his fig. 79, p. 250) the branches are remarkably similar to those in man, but do not conform to any branching patterns found in our rhesus material. Miller ('39) studied the relations of the axillary artery to the brachial plexus in 480 routine dissections of human bodies and in dissections of 17 species of primates; among the latter is 1 specimen of Macacus rhesus in which, according to her figure 19, the axillary-plexus relations

are similar to the most frequent relations found in our material (see fig. 24).

In man the axillary artery has been studied intensively by a number of workers, yet a comparison of their findings is rendered peculiarly difficult because of the diverse methods of their study and presentation. Hitzrot ('01) in 47 "cases" distinguishes 7 branching types of the axillary artery, but does not mention race in connection with his study. Poynter ('23) in his very thorough bibliographic work also includes 200 bodies in which he has observed variations of axillary branches; however, he neither types the whole artery as to branching patterns nor states the racial composition of his material. De Garis and Swartley ('28) in 512 arms find different normal (most frequent) patterns of axillary branching in Negroes than in Whites, respective normals occurring in 52% of Negroes and 73.3% of Whites. On the other hand Trotter et al. ('30) in a collective investigation of 384 arms find no significant racial difference of incidence in normal axillary branching for their male series, but do find among 10 White and 27 Negro females that the normal arrangement occurs in 55% of Whites and in only 30% of Negroes. P'an ('40) finds the axillary artery normal in but 27.1% of 140 arms of Chinese. Adachi ('28) in his careful study of 572 arms of Japanese considers the axillary artery in its various relations to the brachial plexus and describes varieties of separate axillary branches, but does not assemble his material into whole patterns of the parent artery. Miller ('39) in her examination of 480 human dissections considers only those anomalies of the axillary branches which are accompanied by aberrant arrangements of the brachial plexus; these anomalous relationships occur in 8% of the dissections, but no mention is made of racial differences.

From the above citations it is seen that at present no broad basis of agreement can be found for comparing the axillary branching patterns in diverse races of man, as a result of which lack of agreement any comparison of the axillary in

man and other primates, such as rhesus monkey, must remain tentative and inviting of further study.

SUMMARY

In 150 specimens of Macacus rhesus (300 upper extremities) the subclavian-axillary arteries are dissected with special reference to their branches, then classified as to normal and variant patterns. The normal medio-lateral order of subclavian branches is: vertebralis; cervicalis profunda; intercostalis suprema; cervicalis ascendens; common trunk for mammaria interna and transversa scapulae (incidence of normal 72%). Variants mainly involve diverse arrangements of branches that normally arise from the common trunk. No thyreoidea inferior is found in any specimen. The axillary artery in rhesus normally has but 2 branches, both being common trunks. The proximal trunk gives off the thoracoacromialis and thoracalis lateralis (incidence 47%); the distal trunk gives off the subscapularis and the humeral circumflex arteries (incidence 85%). Variants usually concern direct origin from the axillary of branches that normally arise from one of the common trunks. Relations of the subclavian-axillary artery to the brachial plexus are figured. Comparison of normal and variant branching patterns of this arterial channel in rhesus with those in man shows that rhesus has more separate subclavian branches but far less separate axillary branches than has man. From available data it appears that rhesus monkeys are less variable in subclavian-axillary branching than are Whites, and Whites less variable than Negroes. In rhesus bilateral symmetry of branching occurs in all but 2 specimens.

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II Congreso Indigenista Interamericano.— It is planned to hold the Second Inter-American Indianist Congress at Cuzco, Peru, June 24–July 4 of this year. The program will include 5 sections: (1) General and human biology; (2) Anthropology; (3) Socio-economics; (4) Education; and (5) Legal aspects. The first Congress was held at Pátzcuaro, Mexico, April 14–24, 1940.

The Duckworth Laboratory.— A laboratory of physical anthropology, appropriately commemorating the name of Dr. W. L. H.

Duckworth, first University Lecturer in that subject, was established [in the Museum of Archeology and of Ethnology in the University of Cambridge] in 1940, under the direction of Mr. J. C. Trevor. During Mr. Trevor's absence on active service abroad Mr. K. L. Little acted as his deputy . . .

Between 1940 and 1944, Mr. Trevor . . . was able to devote his periods of leave from the Army in East Africa entirely to collecting archaeological, ethnographical and skeletal specimens for the Museum, taking cinematograph films of the Ituri pygmies and Tutsi in the Belgian Congo and Ruanda, and carrying out an anthropometric study of the Sandawe and Nyaturu tribes of Central Tanganyika. In addition to the skull and extremities of a chimpanzee from the southeastern shores of Lake Tanganyika, which are thought to belong to the most southerly representative of this ape yet recovered and which were brought home by Mr. Trevor in 1945, the following material, destined to form part of the Laboratory collections, is at present in Nairobi, awaiting shipment to England:

1. The remains of approximately a dozen individuals of Neolithic date, excavated from 2 communal graves in the Ngorongoro Crater of Northern Tanganyika in 1941. Six skulls have so far been restored.

2. The skulls and other bones of 70 male Somali, collected from various localities in British and Italian Somaliland during 1941 and added to later. Only 17 Somali crania have hitherto been described in the literature.

3. The complete skeleton of an adult male mountain gorilla (Gorilla gorilla berengei) and the skull of an adult male chimpanzee (Pan satyrus schweinfurthi) obtained through the courtesy of H.E. the Governor-General of the Belgian Congo as the result of a visit in 1942.

4. The skeletons of 68 male and female Haya, recovered from the burial caves on Musira Island, Lake Victoria, in 1943. It is understood that these represent the first substantial series of Lacustrine Bantu remains yet secured for purposes of study.

Towards the end of 1945, there were 2 unparalleled accessions to the somewhat limited number (less than 200) of human crania in the Laboratory which have, it is believed, made its osteological collections the most valuable and extensive of their kind in the world. These comprised respectively some 10,000 crania, together with other bones, collected by the late Karl Pearson, F.R.S., and presented by his son Professor E. S. Pearson, and about 7000 presented by Dr. W. L. H. Duckworth, former Master of Jesus College and Emeritus Reader in Human Anatomy.— University of Cambridge. Ann. Rep. Faculty Board Arch. and Anthrop. on the Mus. Arch. and Ethnol. (1939–1945 and 1945–1946), January 29, 1947, 7 pp.

REVIEWS

OUTLINE OF ANTHROPOLOGY. By MELVILLE JACOBS AND BERNARD J. STERN. College Outline Series. Barnes and Noble, Inc., N. Y., xiv + 332 pp., 1947 ($1.25).

(This review is concerned only with the 2 chapters on physical anthropology: no. 2, Human evolution, and no. 3, The living races. Neither author is a specialist in this field, and these critical comments should not prejudice the reader against the contents of other chapters — Ed.)

The appearance of a volume on anthropology in the College Outline Series is symbolic of the expansion of anthropology in recent years. This science is ceasing to be esoteric and is taking its place among the established disciplines. An effective outline would be of the greatest aid to both students and teachers. Therefore, it is with real regret that I feel that the present attempt, so far as it concerns physical anthropology, must be considered inadequate. An outline for college students should indicate the scope of a field, outline its problems, methods, and major schools of thought. Since outlining is a difficult matter (all human evolution in 71 pages!), I have compared the "Outline of Anthropology" to portions of the Zoology outline in the same series. The comparison shows that purpose, methods, and differences of opinion can be outlined, even in the small space allowed. By contrast the outline of physical anthropology seems dogmatic and inaccurate. No real attempt has been made to outline human evolution, to indicate the methods used, or appreciate the differences in personal opinions. The authors have elected to give us their own ideas.

For example, it is stated that, "one division of the tarsiers was on the direct line of ancestry that led to modern humans." The student is presented with the tarsier hypothesis, certainly highly debatable, with no indication of the nature of the evidence, and without even the suggestion that there are other points of view.

This dogmatic approach to the problems of evolution is stultifying, but worse are the authors' numerous statements for which there is no direct evidence. It is stated that Eocene tarsiers "learned more than lemurs" and that, "Virtually all the monkey populations of the Oligocene period and later were diurnal." This may be true,

but there is not even 1 skull from the Oligocene to prove it. The author's derivation of apes from giant monkeys in the Miocene is certainly hard to understand, and the usual points of view might at least be indicated. When Dryopithecus is described as bipedal, omniverous, and even his "cries, shrieks, and calls" are mentioned, it becomes clear that the authors are writing what they personally imagine and are making no attempt to outline the facts and theories of human evolution. The whole question of the time of appearance of modern man and of the interrelations of Pleistocene hominids is ignored by speaking of Piltdown-Heidelberg, Swanscombe-Galley Hill — Steinheim, and Solo-Wadjak-Keilor developmental levels. Do the authors find that none of the theories of the authorities on ancient man are worth outlining?

The chapter on living races is better than that on human evolution. However, the authors dismiss blood groups as useless, and so rule out the most promising developments in the field of racial studies. There is no clear statement of the methods of racial classification, and the distinction between ideal types and populations is never made. Therefore, the treatment of such groups as the Nordic is uncertain, and the reader is left wondering why the authors happen to recognize 11 major races.

Since this outline gives only a partial and distorted view of the facts, methods, and theories of human evolution, it will not be helpful to the college student.

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ANTHROPOLOGIA HELVETICA. Ergebnisse anthropologischer Untersuchungen an den schweizerischen Stellungspflichtigen. I. Die Anthropologie der Eidgenossenschaft, A. Textband, B. Atlas. By Otto Schlaginhaufen. Archiv der Julius Klaus-Stiftung, Ergänzungsband zu Band XXI, Art. Institut Orell Füssli A.-G. Zürich, 699 pp., 499 tables, 144 figures, 161 maps, 168 plates, 1946. (Sfr. 60.)

Dr. Schlaginhaufen, the honored dean of European anthropometrists, presents in these 2 volumes a report of his really monumental anthropometric survey of Switzerland, carried out on army recruits with the cooperation of the Federal War Department. It is a conscientious statement of general results. Dr. Schlaginhaufen might simply have stated that, in the summers of 1927 through 1932, he directed a total of 172 assistants in the measuring of 35,511 recruits,

and worked out the results on Hollerith equipment. Instead, happily, he describes in full detail the organization and procedure of his work, a matter of no small interest (he reports, for example, how the military specified that he could have each subject for an average of 3 minutes, and how this was met by using 2 teams at each measuring station and strictly standardizing routine, so that one subject could be dealt with completely in 6 minutes). Measurements taken were 14 of the most usual ones; hair form and color, eye color, and profile of nose and occiput were observed. (The importance of describing one's measuring techniques minutely, which is really seldom done, is revealed in the fact that these workers, following Martin and contrary to Americans, do *not* use pressure in measuring head length, head breadth, etc.) The project as a whole was financed by the Julius Klaus-Stiftung.

This report is purely descriptive, all special analysis being reserved for the future. It simply gives statistical constants and graphs of frequency distributions for each character investigated, as well as the means, etc., for each canton, and the maps (which, with photographs of a large number of subjects, form the second volume), showing the cantonal variation in different features, supplement and amplify the figures. In stature, the secular increase is shown to have continued, from 163.5 cm in 1884–1891 up to 168.56 at the time of this research. The cephalic index, however, has fallen slightly in all places where a comparison can be made; i.e. the trend to brachycephaly seems to have been checked, which Schlaginhaufen suggests may be connected with rising stature.

Apart from presenting his straightforward averages and percentages, Dr. Schlaginhaufen in the second part of his treatise gives sortings of his subjects by combinations of characteristics, using from 2 up to 6 features at a time. The last such sorting affords 1590 different combinations of stature, head form, face form, nose form, eye color and hair color. The largest combination contains 612 men, or 1.77% of the total; this and the next largest groupings show, as earlier tables of means indicate, that the most usual Swiss recruit is brown-haired, mixed-eyed, medium to tall, meso to brachy, and narrow-nosed.

At the end, and well aware of what he is going to find, Dr. Schlaginhaufen selects the individuals who would conform to the ideals of the conventional European racial types, in the 6 characters named above. Of "Alpines," he finds only 1.41%, and all 6 of the "pure" racial types, liberally interpreted, account for only 8.66% of the Swiss. All this is treated only as a demonstration, however; the one purpose of the treatise is an accurate anthropometric record of Swiss recruits, canton by canton, during the years of the investigation, and Dr.

Schlaginhaufen points to the great variety of physical form as the main fact of general significance. Physical anthropologists will find this weighty report valuable, not only for the picture it presents of a whole nation, but also as a source of information on the purely statistical aspects of a very large series.

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LES ARMÉNIENS: Introduction a l'Anthropologie du Caucase. By R. KHÉRUMIAN. Preface by H. -V. VALLOIS. Librairie Orientaliste Paul Geuthner, Paris, 298 pp., 8 maps, 192 figures, bibliography, indices, 1943.

This work is ostensibly a report on the anthropometry of some 600 Armenians. Paradoxically, it is both a good deal more and a good deal less.

The author has divided his study into 5 main chapters and a final brief summary.

Chapter I, *Données Demographiques*, offers some sketchy demographic data. Of greatest interest, perhaps, is the estimate of the total Armenian population which is given as 3,600,000, of which 90% can be found either within the territories of historic Armenia or in immediately adjacent countries. The birth rate for the Armenians in the Armenian Soviet is given as 57.8 per thousand and the death rate as 17.5. Age groupings show a clear predominance of younger elements, and the sex ratio is figured as 977.6 females to 1000 males. Eighty-one per cent of the population in the Armenian Soviet is reported as peasant, while among the *emigrés* this proportion is markedly lower.

Chapter II, *Somatologie des Arméniens*, deals with the author's own material. While the figures are of interest, there are certain weaknesses in the presentation. Although the size of the series is given as 600 in the introduction, the major part of the discussion is limited to 351 adult males. Data on 154 women is referred to only occasionally, and the 112 children and adolescents (48 girls and 64 boys) are mentioned only in relation to age of maturation and to pigmentation.

This reviewer looked in vain for a clear statement as to the nature of the sample and the circumstances under which it was studied. His impression is that the subjects were probably drawn from Armenian families resident in France, but he is far from certain. There is no presentation of the geographic distribution of the subjects apart from

a rough division into eastern and western groups, and their origins are merely summed up as diverse. Because of the nature of the argument and the small size of the sample these are rather serious omissions, although they are partly compensated by the use of considerable comparative data. (In this regard it should be stated that Hughes' material as cited by Coon could not be used, for the author did not receive a copy of *The Races of Europe* until after his manuscript was virtually complete.)

The series of adult males is divided into an eastern group of 115 and a western group numbering 236. By east is meant the highland area extending eastward from the headwaters of the Halys River to the Caspian Sea and from north of Tiflis to south of Van. The western division includes Thrace and western Turkey as far east as Ankara. It is not clear in which group Cilicia and Syria are classed, or whether the sample includes individuals from either of these provinces or from the so-called "central" area of the Halys River drainage.

Stature is considered as a prime racial factor and an occupational difference between agricultural and professional groups shows the professional class to be markedly taller. This difference is interpreted as being due to a racial factor, but no other data are cited to support this assumption.

Because of the small size of the sample and its lack of definite geographic location it is useless to cite exact figures. In general the anthropometric data accord well with other studies of Armenians, and the eastern group appears as taller, a little less brachycephalic, with longer face and nose, and with occipital flattening appearing a little more often.

The young show a much higher degree of blondism, which is apparently suppressed with age. The reverse is true in eye color, where light eyes are less frequent among the young. This situation suggests a recessive character in light pigmentation and accords well with the author's interpretation of a Nordic element being present.

The blood group proportions are normal for western Europe (O 37.4; A 47.3; B 9.6; AB 5.7).

The age of menarche is reported for 157 women. The mean is given as 14 years with 70% falling between the ages of 13 and 15 years and with a total range from 11 to 19. The author found no essential difference between the eastern and western subgroups.

The age of menopause was recorded for only 31 subjects. The mean is 45 years, 1 month and 16 days, and the range is from 36 to 54. This number is so small, however, that the figures are of doubtful value.

Chapter III, *Composition Raciale du Peuple Arménien.* In this section the author tries not only to analyze the racial components of his series, but also to define the "so-called Armenoid" type. (Quotation marks his.)

Following a detailed comparison of Armenoid and Dinaric series, the author pays specific attention to the 4 characters (stature, body proportion, nose form, and chin prominence) which are usually cited as distinguishing the 2 groups. With considerable justification he holds that the difference in stature is more apparent than real, for he argues that the maximum stature recorded for Dinarics in Montenegro and Herzegovina should be compared only with those Armenoid districts of maximum stature such as Akoulis, Kara Kilissa, Kamarlu, Hadjin, etc., where means ranging from 172 to 175 cm were reported by Chantre. Other Dinaric areas range in stature mean from 166 to 169.5 and are similar to Armenian stature means which are cited by various authors as falling in a range of from 167 to 169.5 cm.

Differences in body-build are also viewed as inconsequential, and the author cites Škerlj as to the relative massivity of the Dinarics. This accords well with the reviewer's own data on Montenegrins (cited by Coon, and now in the final stages of manuscript preparation) in which tall stature is not associated with linearity of body-build. The other accepted differences are similarly dismissed.

Reviewing the statements of Bunak, Günther, Fischer, Weinert, Škerlj, Haddon, and Verschuer, the author comes to the conclusion that on morphological grounds the Armenoids should be considered as a part of the Dinaric race and that there is no justification for considering them as a separate racial group.

Chapter IV, *Paléoanthropologie de l'Arménie.* The author starts this section with a summary of the craniological evidence from archaeological sources. For Armenia and the Caucasus he finds an almost complete absence of any brachycephalic element whatsoever until protohistoric times (First Millenium B. C.). For the Near East as a whole his conclusions are similar, and he quite properly discounts the so-called Armenoid characters of the 3 skulls from Kish. Following Krogman and Vallois he considers these and the Egyptian crania as representing primitive Alpines. Brachycephaly and Dinaric characters are cited as appearing earlier and in greater strength in Europe rather than in Asia; the assumed relationship between Alpines and Mongoloids is denied; and the concept of Armenia as the cradle of the Armenoids and Dinarics is pretty well demolished.

Following Bunak with some minor disagreements, M. Khérumian comes to much the same conclusion expressed by Coon and Hughes; namely, that the Dinaric-Armenoid type is essentially a blend between

brachycephalic (European Neolithic) and dolichocephalic (proto-Mediterranean and perhaps Nordic) elements. As a supplementary consideration the author points to the clear differences between the forepart of the skull and face, which he attributes to the influence of a dolichocephalic stock, and the posterior portion, which he believes to be clear-cut evidence of a bracycephalic element.

On historic and linguistic grounds the author next concludes that the Armenians are the descendants of the Phrygians. Since he finds no Armenoid-Dinaric types in Asia Minor before the Thirteenth Century B. C., he correlates their introduction with the Phrygian invasions, but he states with emphasis that he sees this ethnic wave as composed of strong Mediterranean and Nordic elements as well. Citing Krogman, he points out that at Alişar Alpine and Mediterranean type skulls were found equally represented after the Eighth Century B. C. while between 1000 and 700 B. C. only the Mediterraneans seem to have been represented.

The higher proportion of ''Armenoids'' or Dinarics found in the Eastern provinces he thinks is probably the result of 2 factors, the isolation and refuge area character of the eastern mountains, which operated to preserve the type, and the probability that the vanguard of the Phrygian invasion contained a stronger Dinaric component than the later waves which established themselves in the west. In this regard M. Khérumian calls attention to the Muškis (called Phrygians by Winckler and identified as Armenians by E. Forrer) who were reported by the Assyrians as being in the region of Van and Diarbekir about 1167 B. C., and to the Armenoid skulls of Cemetery B at Tepe Sialk. He cites Ghirschmann as dating these latter to approximately 1000 B. C., and notes that their grave furniture is similar to that of the oldest tombs at Gordion.

In a summary statement he sees historic, archaeological, linguistic, and anthropological evidence all pointing to a vast ethnic movement which brought a new element into Asia Minor toward the close of the Second Millenium B. C. This element he considers to be Dinaric.

Chapter V, *Notes sur la Formation Ethnique du Peuple Arménien.* Here M. Khérumian offers a brief historic sketch of the Armenian area. While this section is of considerable interest and serves to coordinate a few references in the previous discussion, it is not interwoven with the rest of the argument and need not concern us here.

Chapter VI, *Résumé et Principales Conclusions.* The author is to be congratulated for compressing into 6 pages an excellent summary which includes much of his principal data, his leading arguments, and his main conclusions.

In addition there is appended an extensive bibliography which includes many Russian sources normally beyond the scope of western scholars.

While exception can be taken to various parts of M. Khérumian's book, particularly to his presentation of his own data, it represents a great deal of work and is a distinct contribution. A great deal of material has been assembled and synthesized, and his major points appear to this reviewer to be sound.

In his prefatory note Dr. Vallois singles out as the 2 most important conclusions the quasinegation of the Armenoids as a racial type distinct from the Dinarics and the view that the brachycephalic types of Asia Minor and the Caucasus were derived from the west, in contradistinction to the long accepted theory that brachycephals were of purely Asiatic origin and that their major movement was from east to west. He also points out that although both these views have been advanced before, this synthesis of craniological, living, and historic data is the most comprehensive treatment yet accorded the subject.

With M. Khérumian's argument for a west to east ethnic movement I find myself in essential agreement. In connection with the analysis of my Montenegrin data I was forced to review the archaeology and history of the Balkans, and I have come to the conclusion that it is impossible to derive the population of the Dinaric area from Asia Minor.

That both Armenoids and Dinarics are the products of the same or similar blends of brachycephalic and dolichocephalic elements has been argued at length by Coon, and M. Khérumian's rejection of the Armenoids as distinct from the Dinarics seems logical.

There is, however, another point which opens up a further field of inquiry. As stated above, M. Khérumian considers the Armenoids as an extension of the Dinaric race, and at the present time I would question the existence of a distinct Dinaric (or Armenoid) racial type in the strict sense of the term. The crux of the matter lies in whether occipital flattening is normally inherited or whether it is the result of an artificial deformation either intentionally or unintentionally produced. M. Khérumian discusses this character very briefly and comes to the conclusion that it is inherited. Since a flattened occiput is correlated both with hyperbrachycephaly and with hypsicephaly, and since all 3 characters are major diagnostics in the identification of both Armenoids and Dinarics, this question is of fundamental importance.

At the meeting of the American Association of Physical Anthropologists in December, 1946, Father John F. Ewing reported on a

study (still in preparation) which compared a series of native born with American born Lebanese Maronites.[1] The difference between the cephalic indices of the 2 groups was striking, as was the high incidence of occipital flattening in the Old World series and its relative absence in the New World. Father Ewing also extended his study to include the geographical distribution of deformation practices.

In a paper given at the same time I reported on an anthropometric series of 851 subjects measured in Montenegro, which was presumably of predominantly Dinaric composition.[2] Here again the evidence suggests that the occipital flattening of the Dinarics is largely due to artificial causes.

It seems perfectly possible that occasionally some degree of flattening can occur through a blending of hereditary factors, but from the nature of the evidence, I do not see how it can be attributed to any specific racial group. Where flattening is found to be characteristic of a population such as the Dinarics and Armenoids it not only crosscuts recognizable racial subgroups, but it also coincides with the distribution of factors leading to artificial deformation.

If we examine M. Khérumian's thesis of a west to east ethnic movement in this light, it remains acceptable. The populations of the so-called Dinaric and Armenoid areas are virtually identical in type, and the recognizable elements are essentially the same. We need only postulate that the migrants from the west carried with them and perhaps diffused practices of infant care which caused an artificial similarity of form, thus accentuating the resemblances already inherent in the 2 populations and masking such differences as may exist.

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[1] See this Journal, n.s., vol. 5, pp. 235–236.
[2] See this Journal, n.s., vol. 5, p. 236.

EL ENGAÑO DE LAS RAZAS. By Fernando Ortiz. Editorial Paginas, La Habana, Cuba, 428 pp., 1946. ($4.00 Cuban.)

As an *éxpose* of misconceptions of race, Professor Ortiz's book is not an original contribution. Somewhat similar studies have become prolific in the United States. Yet it can stand on its own merits. Written in Spanish by a prominent Cuban ethnologist and liberal (the work is dedicated to Henry Wallace), it displays a high grade of scholarship and presents its thesis with clear cogency.

Nothing would be gained by reviewing the book in its entirety. Most of the arguments which Professor Ortiz has so forcefully marshalled against racism are dogma to anthropologists, having long ago become part and parcel of their professional aramentarium. But *El Engaño de las Razas* must be considered distinctive in one important respect: it not only pleads against the traditional errors of race concepts but demands that the very term "race" be abolished by law on the grounds that it is merely a human invention that exists only in the mind. Here the book treads on precarious ground. In point of fact it outdoes even its American counterparts in disparaging the biological definition of race.

It is apparent that Professor Ortiz's real objectives are humanitarian rather than scientific, yet it is questionable that the former goal can be achieved by taking leave of anthropology, which has always been the natural enemy of racism. Anthropologists are given a shabby treatment in this book which they do not deserve; in fact, they are often indiscriminately lumped together with outright racists. One doubts that the type of approach here made will be of greater efficacy in orienting popular thought away from genuinely racist views than that used by anthropology, which, since Boas, has had at least some success in dispelling the misleading and unwholesome connotations of a word now used by almost everyone. The man in the street has eyes and he sees what is quite obvious to anyone — groups of people have hereditary physical differences. But the author proposes to abandon the biological definition of race by denying in effect what is tangible. He replaces it with a complex scientific argument beyond the grasp of those who, if they read at all, read as they run. It is hard to see that in this way he will win more converts than the anthropologist.

Aside from the inefficacy of the negatory approach, it must be deplored from the scientific viewpoint. This is the more serious criticism, as far as the anthropologist is concerned. The latter has painstakingly built up his concept of race so that he might use it not only as a tool for research in human biology and historical reconstruction but also to check dangerous misconcepts. In this he has not been frivolous or hasty. At every turn he is sobered by his realization that there are important gaps in his knowledge. In fact, he is continually confessing this in classrooms, books, and scientific journals. It is unfortunate that Professor Ortiz makes capital of these declarations of inadequacy, which he has culled from a vast variety of sources, without presenting them in their proper context, which is a searching rather than a denial. It is also unfortunate that he continually calls upon genetics to bolster his attack. He makes a great

to-do because anthropologists have failed to isolate genotypic criteria for race, but he fails to acknowledge that this is due to lack of sufficient knowledge rather than a conscious blurring of the facts. Would indeed that it were possible to cast aside the present limitations imposed by the teasing revelations of the phenotype. Yet no one criticizes the zoologist for making classifications on the basis of that which is visual. If geneticists were to buckle down to work on human beings instead of jeering at anthropologists from behind their jars of fruit-flies, perhaps the dilemma might be solved. Until this happens, there is little else to do but continue to classify human groups according to somatic differences, which, while they may give an incomplete picture, at least give clues to the underlying genetic realities.

It is an interesting fact that Professor Ortiz, just like some of his friends in the United States, ultimately falls back upon some word to describe group differences. He suggests two—"androtype" and "ecoandrotype."

As a minor criticism one notes that this work, which is lengthy, lacks a true index and a bibliography. Moreover, though otherwise displaying evidence of careful workmanship, its bibliographic footnotes are often inaccurate. This is no reflection on the text, which, while one may not agree with some of its assertions, displays mature reasoning, good taste, and excellent literary quality.

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THE FACE IN PROFILE. An Anthropological X-ray Investigation on Swedish Children and Conscripts. By Arne Björk. Svensk Tandläkare-Tidskrift, Lund, vol. 40, no. 5B, 180 pp., 34 tables, 65 figures. 1947.

This study is one of the excellent series to come out of Dahlberg's "State Institute of Human Genetics and Race Biology" at Uppsala. Björk's study is a cephalometric analysis of cranio-facial proportions in various degrees and types of prognathism as viewed roentgenographically from norma lateralis sinistra. It is, therefore, a contribution to the morphology of dental malocclusion. Björk defines his aim thusly: "The purpose of this investigation is therefore to examine the normal variations and the mechanics of prognathism as well as the relationship between the facial build and the bite in representative material" (p. 26).

The material upon which this study is based consists of lateral head-plates of the following series: (1) 20 12-year-old boys, x-rayed on 2 different occasions in order to determine methodological error; (2) 322 boys between 12–13 years of age; (3) 281 young male conscripts between 21–23 years of age.

The roentgenographic technique used is a blend of the Lysholm cranial table and the Broadbent-Bolton cephalometer. Björk adapted these 2 to a portable unit, to be affixed to the wall, adjustable for height. Pictures are taken so that there is a constant 90-mm. distance between film and mid-sagittal plane of the head. Distance between focus and mid-sagittal plane is held at 155 cm. This general lay-out gives an average picture (shadow) magnification of 6%. Björk establishes his mid-sagittal plane as at right angles to a plane through the ear-holes and through subnasale. Pictures are taken with ear-rods, a locator on subnasale, and a chin rest, all for stability. A Siemens radiosphere, with a Siemens telephoto tube, was used.

Björk marked 24 points on each lateral x-ray. They are conventional cephalometric points for the most part, though he uses 1 new one, *articulare,* defined as "the point of intersection of the dorsal contours of proc. articularis mandibulae with os temporale." On his experimental series of 40 x-rays (20 subjects taken twice) he finds a certain amount of error, partly due to the fact that no head or face is precisely bilaterally symmetrical, partly due to overlap caused by errors of projection. From experience I am ready to grant the former, but I feel that Björk's technique is in part responsible for the latter. With precise head orientation and a more accurately rigid head-holding mechanism he should cut projection error to a minimum. I feel also that he has not allowed enough for the fact that right and left sides are at differing distances from the film. Where he has overlapping at *articulare (a)* and at mandibular angle *(kk)* he uses a as the mid-point of a_1 and a_2 (the two projected sides); kk is similarly the mid-point of kk_1 and kk_2. In doing this Björk is not consistent with the more usual method of choosing *one* side (the one with least magnification) and following it throughout.

From the 24 points located on the film Björk marked off 31 dimensional lines and 55 angular measurements between these lines. All of these were tested for error (3 × its S.E., "significant," 2.5–3.0 × S.E., "probable.").

In the linear measurements he found errors, σ_1, to be between 0.3 and 1.1 mm., except for length of base of upper jaw, where it amounted to 1.4 mm. The angular measurements showed errors of 0.3° to 1.6°. To those of us working on problems of cranio-facial growth it is important to note that Björk found nasion and articulare

to be "satisfactory points of measurements, while porion and the Bolton point must be regarded as inferior points" (p. 39).

Björk used a modified version of the basic Hellman concept of the "profilograph" as his unit of analysis and comparison. He uses nasion *(n)*, mid-point of sella turcica *(s)*, articulare *(a)*, the jaw angle *(kk)*, the chin point *(dd)*, infradentale *(id)*, and the tip of the anterior nasal spine *(sp)*. Maxillary prognathism may be caused by a reduction in the saddle angle (n-s-a), a reduction at the jaw joint (s-a-kk), or an increase in the chin angle (kk-dd-id). It may also be caused by a shortening of the cranial base (line n-s-a) or an elongation of the jaws.

The theme of variation is set by plotting M $\pm$ 1 S.D. for the angles and dimensions. Typical profiles, thus constructed, are seen in his figures 18 (for conscripts, p. 63) and 52 (for boys, p. 125). These 2 figures serve, as is to be expected, for Björk's analysis of "growth." He is, of course, warranted in using the term, but strictly speaking he is merely recording *age-change*. The 2 samples are comparable only insofar as both are drawn from the Swedish population. Björk is comparing 2 age-groups, each represented by 1 static cross-sectional observation. This part of the study, therefore, cannot be considered as truly representing the dynamics of growth progress over a 10–11 year period. With this reservation before us, his findings are still quite suggestive.

The author confirms previous results when he says "that linear growth changes in the various parts of the face vary widely." (p. 170). Thus, cranial base increases 6–8% while length of jaw (upper and lower) increases 10–11%. This results in slightly increased prognathism, with the angle s-na-pr increasing 1.2°. The frontal height of the face, na-gn, increases 13%, but upper and lower jaws grow at different rates: upper (na to upper Il) increase 10%, while lower (lower Il to gn) increases 15%. Ramal height increases 26%. With this ramal growth the lower jaw moves slightly forward relative to the upper; the angle of mandibular prognathism (s-na-pog) increases 2.8°. While this is happening the facial profile angle (na-pr-pog) is increasing 4.4°. Thus the boy's pattern changes symmetrically to that of the young adult (conscript), for simultaneously the chin angle is reduced 4.3°.

A point of great interest is the statement that "maxillary and mandibular prognathism occur simultaneously . . . " (p. 171). This produces total prognathism. The r between the 2 is $+0.67$.

Orthodontic findings in this study are intriguing. Björk first sets up his cases in a modified Angle scheme: *Class O + I*, embraces Class

O without malocclusion (64 cases) and Class I with malocclusion (146 cases); Class II, distal occlusion, embraces Class II, Division 1, cases of protrusion (25 cases), and Class II, Division 2, cases of recession of the upper incisors (20 cases); *Class III*, embraces mesial occlusion (26 cases) (see pp. 120–121). In 3 figures, 49–51 (pp. 122–123) Björk charts the frequency of horizontal over-bite (occlusion of the incisors), molar occlusion, and vertical over-bite in the several classes. Horizontal over-bite and molar occlusion seem to parallel one another. Cases of extreme maxillary over-bite (which he calls "positive over-bite") are limited to Class II/1, while those of mandibular over-bite ("negative over-bite") occur in Class III. Vertical over-bite tends to be distributed fairly equally among the Classes. Average molar occlusion and horizontal and vertical over-bite are distributed about equally in Classes O and I. Another finding of orthodontic import is that as between the boys and the conscripts the incisor axes tend to become more vertical with age. Björk also found that "basal prognathism increases at a greater rate during the growth period than does the alveolar prognathism" (p. 172). The final conclusion concerning the Angle classification is that it "is based upon changes within the bite which do not clearly differentiate between the various classes" and further that "the division into Classes is largely dependent upon the investigator's judgment and experience" (p. 121).

This is an important study. It is terrifically compact. I found myself unable to read and assimilate more than about 10 pages per evening — and then had to review again and again before I could go on. Björk has rendered an extremely valuable service in testing the roentgenographic cephalometric technique. The errors he reports are well within the finite values of biological measurement generally. They will not, in my experience, seriously influence analysis and interpretation.

"The Face in Profile" is essentially a fact-finding report. In cases of positive or negative over-bite Björk merely views and estimates, as it were, the dimensional and angular relations in an *attained* condition. To some extent the comparison between boys and conscripts gives some idea of *how* the condition was attained. But in this study, as a whole, the author has not told us — nor can he tell us — of the etiologic factors involved. This, let me hasten to say, does not detract from the value of the present study as a critical first approach. It merely underlines my hope that Björk will carry on his important researches and will give us next a thorough longitudinal growth analysis and growth progress assessment.

The report is copiously illustrated, and carefully documented. There is a good bibliography. For growth students and craniometricians alike this is required study.

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DICE OF DESTINY. By David C. Rife. Second ed. Long's College Book Co., Columbus, Ohio, 179 pp. ($2.50).

The second edition of this "popularly written" book on human genetics by the Professor of Zoology at Ohio State University differs from the first chiefly in the addition of sundry appendices, including a glossary and certain technical genetic formulae. The elimination of the snowstorm of typographical errors that made certain parts of the first edition wellnigh unintelligible is a notable improvement. Other curious features of the text have not been altered. A startling indifference to the rules of grammar and syntax (e.g. "The parent may be a heavy drinker because his genotype is such that he likes it very much"— p. 16), combined with a peculiar dead-pan clowning (e.g. "hair color has a marked effect on our looks"— p. 35), creates a flavor hard to describe and sometimes hard to take.

The "dice" in Dr. Rife's title are the genes, whose random segregation cast each of us in a unique genetic role at conception. Yet the author is frankly skeptical that his readers will have the mental acuity to grasp the relationship between genes and chromosomes. His failure to link the genetic processes into the beautifully exact mechanism of cell division, mitotic and meiotic, classes this book as a Sunday-supplement exposition of scientific truth. The reason for using this approach is that "A discussion of chromosomes would naturally raise the question of linkage versus random assortment of genes. During the periods of time required for the evolution of races all genes, whether linked or not, appear with independent frequencies in the various racial groups" (p. 6). Since Rife points out elsewhere in the book that the various alleles within the same racial group are also randomly distributed at any time this reason given for ignoring the chromosomes is specious. Actually most of the book is devoted to the genetics of individual differences rather than to the genetics of population, and the situation gets out of hand in the chapter on sex-linkage. Since in this phenomenon genes *are* linked, some explanation must be

forthcoming. Hence we are informed that "A certain group or block of genes occurs singly in males, but in the paired condition in females" (p. 3), which reduces chromosomeless genetics to something of an absurdity. To keep up appearances the glossary offers this odd definition: "Sex-linked — Genes which occur singly in males, and in pairs in females, as those responsible for color blindness and hemophilia." The word "sex-linked" is obviously not a noun, and it is not "genes"; it is an adjective to describe a peculiar criss-cross pattern of inheritance, meaningless unless the chromosome mechanism is understood (in fowls sex-linked genes occur paired in males and singly in females). This failure to achieve a clear and exact use of genetic terminology adds considerably to the basic confusion.

Perhaps the author's dead-pan humor will help the reader to forget his perplexity over such matters, but it does not clarify the situation. Here are some samples of the comic relief that is sprinkled at random through the book:

"Haldane believes that all should be kept in institutions rather than sterilized." (p. 128.)

"Contraception has the advantage of being reversible." (p. 129.)

"The primary attribute of a male is the ability to produce sperms, and that of a female the ability to produce ova. It is a matter of common observation, however, that the sexes differ in many other respects." (p. 50.)

"The ability to learn new things was demonstrated by Pavlov, a Russian physiologist. His experiments are now classic." (p. 87.)

"The adage "gentlemen prefer blonds" has been shown to be not entirely true." (p. 35.)

But enough clowning. Dr. Rife is at his best in his brief survey of population genetics. Even here, however, there are some errors of fact and interpretation. After a good discussion of the utility and limitations of sterilization and a survey of some of the promises and pitfalls of eugenics, he closes with the following statement: "The limit in any given direction would be attained when the race was homozygous for all effective genes. The greater the number of traits selected for, the longer would be the time required to reach the ideal. Once achieved, the race would remain stable, aside from occasional mutations, until another ideal was set up." In any realistic context it is wholly impractical to postulate the creation of a homozygous strain of the human race, a project that would take thousands of years. Once that has been achieved we are stuck so far as further progress toward other "ideals" is concerned. The fact that the "ideal had changed" would alter the homozygosity not one whit. The "ideal" of a homozygous human race is mercifully beyond our grasp, so the whole passage borders on being biological nonsense.

The main theme of the book — the genetic differences in human beings and the social and political implications thereof — is a very

important matter, which deserves much wider consideration than it is getting today. There is urgent need for its presentation in concise simple treatises. But the people who need to know these things will not learn them from experts who have not clarified their thinking.

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SEXUAL BEHAVIOR IN THE HUMAN MALE. By Alfred C. Kinsey, W. B. Pomeroy and C. E. Martin. ix + 804 pp., 173 figures, 162 tables. W. B. Saunders Co., Philadelphia, 1948 ($6.50).

To paraphrase, every one talks about human sexual behavior, but Professor Kinsey and his associates have done something about it! The present report, on the male, is but the first of 9 volumes to cover every possible aspect of sexual behavior in these United States. To date they have 12,000 case histories, with 88,000 to go. Of these 6300 are male, of which 5300 — the nucleus of this report — are white males. In the gathering thereof Kinsey has chalked up 57.6%, Pomeroy 31.2%, Martin 7.3%, and "others" 3.9%. Every occupational group, from auto-mechanic to zinc-worker and anthropologist to zoologist, has been covered; and every stratum of American life. If they've failed to mention any American white male series I didn't discover it. The total material has a 12-way breakdown: sex, race-cultural group, marital status, age, age at adolescence, educational level, occupational class of subject, occupational class of parent, rural-urban background, religious group, religious adherence, and geographic origin.

It should be obvious that break-downs such as these must inevitably affect sample-size. And they do, for some samples verge upon statistical inadequacy. Another factor worthy of note is that the source-data are skewed in the direction of the higher educational levels. Finally, the case-history interview method, as set up, is trended in the direction of those who, for one reason or another, wish to "tell all." The authors have taken due cognizance of these 3 sets of conditioning factors. The interpretations [which are at a minimum] are cautious and the conclusions are conservative. As far as I could discern the report made no claim or assertions other than the data themselves suggested. There is an evident check and cross-check all along the line.

The nexus of this report is to be found in the analysis of frequency of orgasm in the white male. Kinsey sets up 6 primary sources of

sexual outlet: masturbation, nocturnal emission, petting, heterosexual intercourse, homosexual intercourse, animal intercourse. These outlets, or combinations thereof, provide form and substance to male human sexual behavior.

An important socio-cultural distinction is set up when the data are considered at 3 educational levels: (1) grade school (in whole or in part) only; (2) grade school plus high school (latter in whole or in part); 3) grade school, plus high school, plus college (latter in whole or in part). Kinsey finds that boys of group 1 have their first ejaculation (usually self-induced) at 14.58 years, those in group 2 at 13.97 years, those in group 3 at 13.71 years. He then states that "99% of the boys begin regular sexual lives immediately after the first ejaculation," (p. 192) i.e., regular in the sense that one or more of the outlets is consistently achieved. Masturbation is most frequent, though Kinsey says that while 88% of males practice it from 16–20 years, it is only two-thirds of the total outlet. From his as yet inadequate female data he states that "the female population is 29 years old before it includes as high a per cent of experienced individuals as is to be found in the male curve [of orgasm] at 15." (p. 187.) The highest rate of outlet in the male is between adolescence and 20 years. The type of outlet varies with the social class: masturbation and petting in the higher, heterosexual intercourse in the lower.

A fact of biological importance is that the earlier-maturing boys appear to have, from then on, a longer-lasting and more vigorous sex-life. This finding corroborates growth-pattern studies in early-, mid-, and late-maturing boys generally.

The facts just enumerated are of great bio-socio-psychological import. The terrific sexual activity of the adolescent and post-adolescent boy must be faced: in the home, by the Church, in boarding schools, in any situation where boys are to be guided, either individually or en masse. There is another phase of the problem, viz., that definitions and patterns of sexual behavior vary from class to class. "Right" and "wrong," morally and legally, can be defined only within the social framework in which they occur. Finally, "normal" cannot be assessed as merely the usual or conformant, "abnormal" the unusual or deviant. These social implications are set forth in greater detail by Kinsey on pp. 441–447 of the report. I strongly suggest that they be made *required reading* by every thinking and responsible adult. I quote one outstanding finding: "Exceedingly few males modify their attitudes on matters of sex, or change their patterns of overt behavior in any fundamental way, after their middle teens" (p. 446). Add to this that "children are the most frequent agents for the

transmission of the sexual mores'' (p. 445) and the problem of sex education becomes compounded.

In this review I could recite facts and figures by the ream. I'm not going to. I urge you to read them yourself — for this book is a *must* (if you'll pardon the cliché) for every physical anthopologist. We call ourselves human biologists: Kinsey has studied a basic biologic process in the human animal and has translated his findings into bio-social behavioral norms. It is our job to understand all phases of the human male, and that includes incorporating bio-social findings such as these.

In this review I've offered certain methodological criticisms. In so doing I feel as though I'd berated a chap for not counting up to 1000 when he's stopped at 998. The job is not perfect, and Kinsey very frankly admits that he could have gathered more anthropological, endocrinological, gynecological, medical, psychological, psychoanalytic, sociological and urological data. But I liked this book because it wasn't all cluttered up, especially with Freudian and pseudo-Freudian analyses masking as ''interpretations.'' Kinsey says, in effect, ''this is *how* American human white males behave sexually.'' I think he wrote a better report because he side-stepped the *why!* He did a first job first. Let the theoreticians now hover.

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New Easy Access to Colombian Indians.— One of the unexpected by-products of the search for new rubber areas occasioned by the critical wartime need was the opening to relatively easy access of South American forest areas having Indian populations almost untouched by modern civilization. This is particularly true of the Rio Vaupés region of southeastern Colombia. Until the rubber program introduced air transport, contact with the outside world was limited almost entirely to the balata workers who occasionally made the river journey to Manaus — a jungle odyssey of 60 days' paddle down the cataract-broken stream. The alternative route was through the forests and across the trackless llanos to Villavicencio, at the foot of the eastern Andes. Today, thanks to the now highly developed Colombian air transport service, one may be in Mitú, the Colombian

government headquarters in the Vaupés Comisaría, within 3 hours flying time from Bogotá. However, short river trips away from Mitú find Indian life continuing in the primitive pattern.— Paul H. Allen. Indians of southeastern Colombia. Geogr. Rev., vol. 37, no. 4, October, 1947, pp. 567–582 (with illustrations of physical types).

Familial Factor in Dental Caries.— The now well-confirmed finding that the drinking of water containing small amounts of fluoride is associated with reduced caries attack rates leads logically to the question as to whether an environmental factor, such as fluoride in drinking water, can overcome, and perhaps obscure, the more basic factor of familial susceptibility in dental disease.

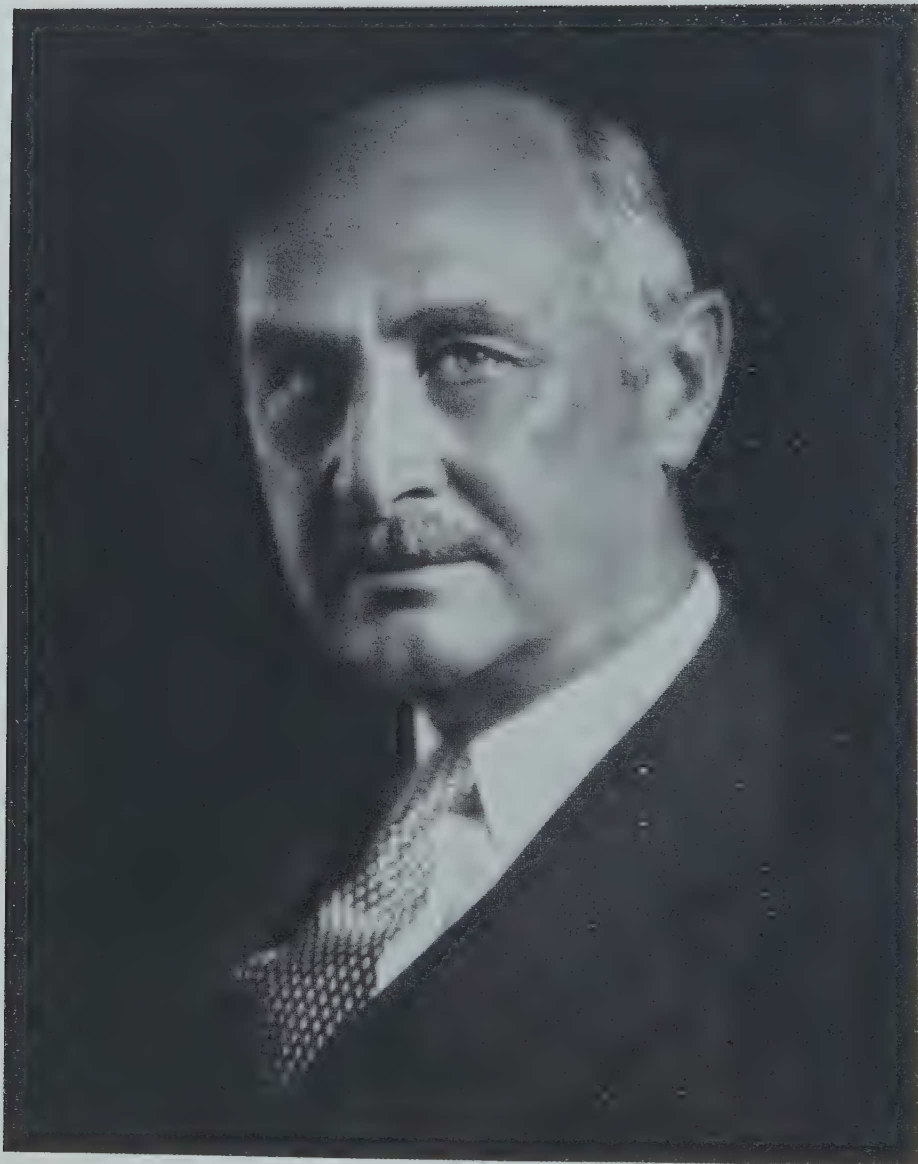
The characteristics of the [New Jersey] population on which the present investigation is based are uniquely appropriate for the investigation. The water supply was accidentally "fluorinated" in 1927, when the water sources were changed from shallow wells (presumably fluorine-free) to deep wells containing naturally from 1.4 to 2.2 p.p.m. fluoride. As a consequence, the older population — the parents — consumed non-fluoride waters during most of the time their caries experience occurred. In contrast, their offspring — the newer generation — have been exposed to the new (fluoride) water all their lives. Hence the opportunity to examine the effects of 19 years of exposure to fluoride-water in an area where such water was not present before . . .

Among the children born and brought up in the fluoride areas those having high DMF [decayed, missing and filled teeth] fathers have higher DMF rates, at almost every age, than do the children who have low DMF fathers. The children of low DMF fathers average at 10 years of age about one-half a DMF tooth and a little more than 2 DMF teeth at 16 years of age. On the other hand, the children of high DMF fathers average 1 DMF tooth at 10 years of age and nearly 4 DMF teeth at 16 years of age . . .

Expressed in other terms, it appears from these data that caries experience in children is determined, among other factors, by familial susceptibility. Exposure to an environmental factor (fluorine in the diet) will reduce the amount of caries attack, but not sufficiently to obscure the influence of the familial factor which may be constitutional in origin.— Henry Klein. The family and dental disease. V. Caries experience among parents and offspring exposed to drinking water containing fluoride. Public Health Rep., vol. 62, no. 35, 1947, pp. 1247–1253.

MILO HELLMAN

1872–1947



Niels Hellman

MILO HELLMAN (1872–1947)

AN APPRAISAL OF HIS UNIFYING INFLUENCE IN ANTHROPOLOGY, ODONTOLOGY AND ORTHODONTIA

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Milo Hellman was born at Jassy, Romania, March 26, 1872. His father was the leader of an orchestra which played at many of the courts and cities in Europe. The young Milo showed musical ability and studied the violin; but his possible career as a violinist was cut short by his own decision that he would much rather be a flutist. After overcoming many difficulties, he succeeded in studying with several famous flutists.

His father died when he was quite young and in 1888, when he was only 16 years old he came to this country, where his older brother was already settled. Five years later, upon attaining his majority he became a naturalized citizen of the United States. For several years he played in small orchestras, finally joining the original Pittsburgh Symphony Orchestra under Victor Herbert, for whom he always had a great regard and admiration.

Gradually he came to the conclusion that, however agreeable it was to be a member of a fine orchestra, the chances for further advancement in the musical world were rather restricted and that if he stayed in the groove he would probably someday be a superannuated flutist, with no pay and but moderate savings. Being exceptionally farsighted, he persisted in his program of self-education and self-financing and by the time he was ready to resign from the orchestra, he had saved up enough to begin his training for dentistry. After passing the Regents Examinations at the New York Prepara-

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tory School, he was admitted to the Dental School of the University of Pennsylvania. He graduated in 1905 at the age of 33 years and soon afterward was married to Miss Helen Michelson of New York.

He took with him to his new profession a fortunate combination of native ability, clear reasoning powers, and a genial presence. He had long since learned well the lessons of self-discipline, team work, accurate observation, manual sensitiveness and dexterity. With his knowledge and appreciation of the great musical works of the past, he had an equal respect for high standards in other professions and for perfection in techniques. His varied contacts with people and cities gave him a certain poise, joined with alertness, that were highly advantageous in dealing with his fellows, and with his patients, both adults and children. Somehow he had developed a healthy skepticism about many accepted beliefs and opinions, both in dentistry and in the world at large. On the other hand, he was ever ready to adopt and apply whatever seemed to be well-grounded on reason and verifiable by observation or experiment.

His subsequent writings and entire life indicate that, as well known to his colleagues and friends, he was motivated by consistently high ideals and by basic principles that appeared sound. He also had an unfailing zeal for finding out and teaching the best, most practicable, useful answers to the problems incident to human growth and human behavior. In a world full of human beings, it can hardly be said that "he suffered fools gladly." He often fought against what he regarded as errors of fact and mistakes in action, but even his opponents respected him and no one was ever in doubt as to what he was aiming at.

After practicing dentistry for several years in New York, in 1908 he took the course in Dr. Angle's School of Orthodontia and there he learned the basic facts and principles of that branch of dentistry as they were known at that time. The following year, when the Angle School had moved to New London, Connecticut, Hellman continued his studies there,

serving also as demonstrator in model making. Dr. Raymond C. Osburn, who gave lectures in anthropology at the Angle School, opened to Hellman the first glimpses of the vast panorama of evolution and showed him that man's present forms of skull, jaws and teeth were but the latest phase in an age-long series leading far back in the corridors of time. At the Angle School he formed firm friendships with many colleagues. Collectively they founded the Alumni Society of the Angle School of Orthodontia, which deservedly grew in influence as it gave its members a forum for the discussion of their technical problems.

Beginning in 1910, Hellman served for several years as editor of the American Orthodontist. Meanwhile at Columbia University, he was studying anthropology under Professor Franz Boas and genetics under Professor T. H. Morgan. He assisted and collaborated with Boas and Wissler in statistical studies on the growth of children and allied topics. Thus he gained exceptional facility in compiling and calculating metrical data and in constructing charts and diagrams which made clear the significant results. From Morgan he acquired a welcome insight into the basic principles and mechanism of heredity.

About this time he also began his work at the American Museum of Natural History where for many years he spent 1 day a week in making thousands of measurements on the skulls, jaws and teeth of all races of man. Thus he developed a special facility in the rapid and accurate measurement of such material and thereafter his well-filled notebooks were always a source of useful data.

During the productive decades of 1913 to 1943, he collaborated with the present writer in a series of reports on the teeth and jaws of recent and fossil primates, in their bearing on the origin of man and the evolution of human races. But the purpose of the present article is not to summarize the scope of his studies in evolution, anthropology and orthodontia, since all of this has been rather fully done in the recent Milo Hellman Memorial Number of the American

Journal of Orthodontics (vol. 34, no. 1, January, 1948); but rather to refer to that material as the basis for a brief appraisal of Hellman's unifying influence in combining various data from these different sources, so as to create what was virtually a new branch of the science of man.

We may indeed refer to Hellman's version of orthodontia as *orthodontogeny* because, as he saw it, the genesis (evolution and development) of normal tooth-forms, normal dental arches and normal occlusion all need to be known and kept in mind, when planning orthodontic treatment of defects and aberrations. In accordance with this general principle, which Hellman expounded in several papers, he chose as his first criterion for effective occlusion the fitting of the mesio-lingual cusp of the upper first molar into the occlusal fossa of the lower first molar; because that relationship is universal in all really primitive fossil mammals and because it persists in the anthropoid apes and fossil and recent man. He also showed that in malocclusion the crown of the upper first permanent molar was frequently rotated in such a way as to throw the buccal cusps out of their primitive and normal relations; so that in order to get this tooth into effective occlusal relations, it must first be rotated in the opposite direction.

Another instance in which Hellman combined the data of palaeontology with those of anthropology was his quantitative survey of the distribution of the different lower molar crown patterns in recent races of man. Here he showed that the primitive *Dryopithecus* pattern (of 5 cusps in definite relations to the main grooves) was most frequent in M_1 and least so in M_3 and that the percentage frequencies declined as we pass from the Australian aboriginals and native Africans to the mongols and whites.

''Milo Hellman's great contribution to the science of physical anthropology,'' writes Krogman (Hellman Memorial Number) ''can be summarized in one short sentence: He took a technique that was dead and static and vitalized it into one that was alive and dynamic. By this I mean that he

adapted a series of measurements originally designed for adult skulls, and applied them to the heads and faces of living individuals — nay, more than living, growing individuals! In his hands anthropometry (more precisely craniometry) justified its birthright as a precise science. It is in keeping with his use of precise measurement that Dr. Hellman brought to orthodontia a vigorous, uncompromising attitude of scientific objectivity: classification, diagnosis, and procedure were all subservient to a thorough study and analysis of each case under observation and for treatment. If Dr. Hellman's attitude could be reduced to a single phrase, it would be: *Know* your patient — which really means the growth pattern of your patient."

In many of Hellman's papers, some new orthodontic system or alleged panacea which he conceived to be wrong both in principle and in practice was attacked with directness, with a mass of evidence and an incisive analysis. Each controversial paper might seem at first thought to be of minor interest to students either of evolution or of anthropology and to be germane only to the technical questions of a small group of specialists. But Hellman was not satisfied merely to refute errors, he sought diligently to discover the reasons for the errors and for a closer approach to a well-founded conclusion. Indeed even his technical reports on the results of orthodontic treatment illustrate what may be called experimental anthropology; that is a study of the forces of growth and differentiation in action and in reaction against forces imposed by the orthodontist. At the same time his beautifully clear charts and diagrams graphically indicated wherein the individual deviated from the norm of his group and what changes occurred either under natural conditions or in response to the use of orthodontic appliances.

Hellman repeatedly acknowledged that the foundations and much of the superstructure of orthodontia as an organized system were laid and built by Dr. Edward H. Angle. But even before Angle's death his temple of science soon began to be overgrown with an unorganized jungle of new competitive

growths. Year after year Hellman labored to cut down these growths and to mend the holes in the original building. To drop the metaphor, Dr. Angle had held up as an ideal pattern the form and relations of the teeth in the dental arches and in the occlusal relations of certain very well-preserved skulls in his collection. He provided his students with a convenient classification of malocclusion or departures from type and he showed them how, even with his simple appliances, they could induce obstructive teeth to move apart and others to take their correct places in line. But Angle could not tell why the dental arches and occlusion of some treated patients retained their correct relations, long after the removal of their appliances, nor why in others the teeth drifted back or even grew worse than before. Hellman was a determined pioneer in dragging such awkward cases into the open where they could be freely discussed and studied and he never ceased to insist that unfavorable biologic factors including among others unhealthy bone-tissue and gums should all be corrected before orthodontic treatment should begin. From mistakes and failures he often learned what not to do and what were the "conditions unfavorable to orthodontic procedure." Furthermore he showed that in some cases, certain phases of malocclusion in children were corrected by natural processes in the permanent set of teeth without any orthodontic treatment at all.

Undoubtedly Hellman welcomed the growing recognition of the necessity of studying growth patterns from the various aspects of biology, medicine, evolution, anthropology, dentistry and orthodontia, but he felt that there was urgent need for more correlated investigation in all these lines.

In his later years he labored to bring together the best of the knowledge and practice of orthodontia which had been won by himself and his colleagues and to compress the same into a general textbook. It was a serious loss to science that he died before the completion of this work; but fortunately his daughter, Mrs. Edith Hellman Bull, who was his secretary and assistant, has been engaged since shortly after his death in

compiling his extensive bibliography and in assembling the material for his textbook. In the meantime, his colleagues and friends have been taking steps looking toward the foundation of "The Milo Hellman Institute of Dental Research," of which more may be noted in another issue of this Journal. Thus his cumulative influence did not end with his death but is now increasing.

Milo Hellman was my intimate friend and collaborator for many years and no one could ask for a better friend or an abler, more cooperative collaborator.

TO MILO HELLMAN

He found a jungle of unrelated fact.
With caliper and millimeter line
He ordered it so future men can act
In accord with nature's plan, rate and design.

From skulls millenia old and fossil bone
And living men in all their changing stages
He cleared the vast conglomerate unknown
And set with Shakespeare's, Hellman's seven ages.

With creative insight and imagination,
Figures in legions, phalanxes of tables,
He deployed in graph and new configuration
To show the facts opposed to current fables.

Seeker of knowledge, quester of the truth,
He helped toward health and beauty mankind's youth.

MYRON MAGE

PUBLICATIONS OF MILO HELLMAN RELATING TO PHYSICAL ANTHROPOLOGY

(Selected from the full bibliography, Am. J. Orthod., *34* (1): 95–104, 1948.)

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1918 Observations on the form of the dental arch of the orang. Int. J. Orthod., *4:* 45–57.
1919 Dimensions versus form in teeth and their bearing on the morphology of the dental arch. Int. J. Orthod., *5:* 615–643.
1920 The relationship of form to position in teeth and its bearing on occlusion. Dental Items Interest, *42:* 161–188, 250–276. (Also in Int. J. Orthod., *6:* 432–444, 478–490, 530–549; and Trans. Am. Soc. Orthod., 146–200.)

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An interpretation of Angle's classification of malocclusion of the teeth supported by evidence from comparative anatomy and evolution. Dent. Cosmos, *62:* 476–495.

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1923 Nutrition, growth and dentition. Dent. Cosmos, *65:* 34–49. (Also in Trans. Am. Ped. Soc., 1923.)

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The process of dentition and its effect on occlusion. Dent. Cosmos, *65:* 1329–1344.

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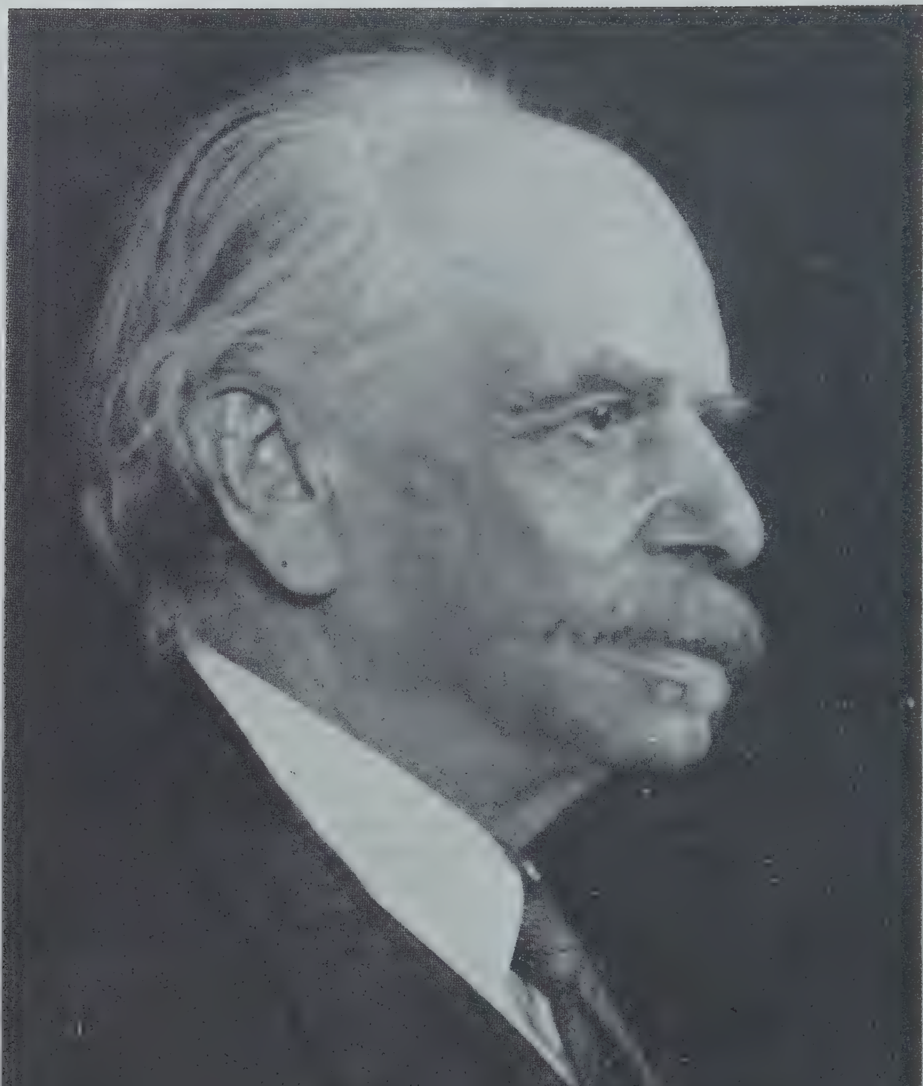
THE SECOND INTER-AMERICAN CONFERENCE ON INDIAN LIFE originally scheduled for June 24 to July 4 in Cuzco, Peru, has been postponed by the Peruvian Government until October 10.

PROBLEMS INVOLVING MIGRATION AND ENVIRONMENT.— I wish to call your attention to certain lines of research which seem to me highly important and to be greatly neglected.

The first of these is migration, especially with reference to its selective effect. One of the most vital questions in regard to any country is the extent to which migration is selective and has a tendency to concentrate particular physical or mental types in special regions. Shapiro has done an excellent piece of work of this kind on the Japanese who have migrated to Hawaii. I have published more speculative studies of the problem in *The Character of Races and Mainsprings of Civilization.* The problem resolves itself into 2 main parts. The first involves actual measurements, tests and criteria of other kinds which differentiate migrants from nonmigrants. The migrants, of course, must be divided into various types such as those who go from villages to towns, from China to regions such as Manchuria, and from China to other countries. The second part of the problem is the extent to which migration, both internally and externally, has influenced the characteristics, both physical and mental, of the Chinese people in the past. In this connection, the effects of nomadic invasions externally and of famines internally, are especially important.

A second problem which seems to me to be of the utmost importance is the effect of the physical environment upon physique, health and capacity for both physical and mental work. It seems to me that there is strong evidence that great differences in actual capacity to work and to think arise from the prevailing state of physical work and energy. The importance of disease in influencing health and energy is widely recognized and is, of course, one of the most important things to be considered. The similar importance of climate and diet is also recognized but has received relatively little attention.— Ellsworth Huntington. Extract from a letter to the Institute of Pacific Relations, dated August 11, 1947.



Franz Boas.

FRANZ BOAS' CONTRIBUTIONS TO PHYSICAL ANTHROPOLOGY

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[Professor Boas died on December 21, 1942. This was at the time when the editorship of the Journal was changing. Regrettably, owing to the difficulties of getting the New Series started during the war period, no obituary notice was published here. It is altogether fitting, therefore, that this analysis of Professor Boas' contributions to physical anthropology, by one of his students, should appear in the Journal on the ninetieth anniversary of his birth — July 9, 1858 — Ed.]

Physical anthropology may well commemorate this, the ninetieth anniversary of the birth of the late Franz Boas, for there are few others, if any, who had as fruitful and profound an influence on the discipline as did Professor Boas. Professor Herskovits has already elaborated on this fact in a penetrating discussion of Professor Boas as a physical anthropologist, and in the same biographical memoir is a paper by Kroeber on Franz Boas: the Man, which also sheds light on his great interest in physical anthropology (Kroeber, et al., '43). Another recent memorial paper on the late Professor Boas for the National Academy of Sciences comments on his role as physical anthropologist (Lowie, '47).

There would seem little more that need be said about the man and his work than has already been related so ably in the aforementioned memoirs. It was suggested to me, however, that a reclassification of the bibliography of Professor Boas in physical anthropology and human biology might well stimulate broader cognizance of his prodigious and fundamental contributions to the field, especially among the younger

men. This I have attempted to do, as well as briefly to note the major problems in physical anthropology as seen by Professor Boas.

The list of publications appended herewith was culled from the complete bibliography of Professor Boas which is given in the memoir by Kroeber, et al. ('43). The titles have been placed under several major headings, namely, (I) Anthropometry; (II) Race; (III) Heredity and environment; (IV) Growth and development; (V) Statistics; and (VI) Boas the citizen, the last category containing a few selections which are indicative of the views held by Boas on important civic issues of his, and our, day. These subdivisions are quite arbitrary, in that the content of many of the papers and books overlap in several or all of the mentioned rubrics. Cross references, it is hoped, will remind the reader of this fact.

It may not be amiss to mention first the relations of Professor Boas to the American Association of Physical Anthropologists and the American Journal of Physical Anthropology. Professor Boas was a charter member of the Association, actively participating in its meetings and committees. At the first meeting of the Association at Charlottesville in 1929, he was appointed Chairman of the "Committee to consider the relations of the Society to the Journal," and retained this post until at least 1938. As early as 1932, reporting for the Committee, he urged that the Journal be made the official organ of the Association, and that annual dues to the latter should include the subscription to the Journal. Precisely this policy was achieved in 1945. Boas served on the Executive Committee of the Association from 1935 to 1938, and was an Associate Editor of the Journal from its inception in 1918.

In the preface of a volume of his selected papers, Boas has epitomized, it seems to me, his philosophy toward anthropology and probably to life in general (111):[1]

[1] Numbers in parentheses refer to like numbered items in appended bibliography of Franz Boas.

Growing up in our own civilization we know little how we ourselves are conditioned by it, how our bodies, our language, our modes of thinking and acting are determined by limits imposed upon us by our environment. Knowledge of the life processes and behavior of man under conditions of life fundamentally different from our own can help us to obtain a freer view of our own lives and of our life problems. *The dynamics of life have always been of greater interest to me than the description of conditions, although I recognize that the latter must form the indispensable material on which to base our conclusions. My endeavors have largely been directed by this point of view.* (Italics added by present writer.)

In conformity with the "point of view" expressed above, Boas himself or through his students initiated a "description of conditions," i.e., a meticulous and vast accumulation of factual material on which conclusions could be based: anthropometric, morphological, and biometric observations on numerous groups of the American Indians, the Eskimo, Puerto Ricans, various immigrant groups in America and their American-born offspring, etc. Almost all of this work, noted in the appended bibliography, was on the living, and as has been remarked by all his associates and is reflected throughout his work, measurements and other observations were made only to solve definite, significant problems, those pertaining to the "dynamics of life." What were some of these problems, and to what extent did Boas consider them solved?

Physical and social anthropology. Boas in his earlier work spoke with apparent equanimity of physical anthropology as becoming exclusively a branch of biology (8) but later sharply qualified this point of view, expressing the belief that "some method must be found, if the important borderland between the two (physical and social anthropology) is not to be neglected — much to the detriment of either" (10). His views on this question would seem especially pertinent in these days since by far most of those contributing to physical anthropology, as exemplified in the pages of the American Journal of Physical Anthropology, are anatomists (Goldstein, '41), most of whom probably have had little or no training in ethnology or sociology.

According to Boas, "It may be conceded that the purely morphological study of early forms of man and of races is a matter that should be treated by the morphologist. It is more doubtful whether the study of living races can be left entirely to him" (10). For the physical anthropologist "must be familiar with ethnic data" in order to answer questions inherent in the study of living races, such as:

> Is the similarity of types living in remote countries due to genetic relationships or to parallel mutations?
>
> What role has domestication played in the development of races?
>
> In how far have anthropometric measures a taxonomic value showing genetic relationship, or in how far are they determined by environment or selection?

These questions are returned to time and again by Professor Boas and will be touched upon in the material to follow. At the moment another example may be given in which the sociological background was considered by him essential, namely, the study of race mixture. For,

> Where it can be proved historically that a population is mixed, such as the American Mulattoes, the half-blood Indians, or the half-castes of the Orient, biological questions arise that require a thorough knowledge of social conditions. If it were true, as has been claimed so often, that mixed bloods are inferior in physique to their parents of pure stock, or that disharmonies of forms will develop that have detrimental effects, it must still be asked who were the parents? Were they of normal value, or of inferior strains in the race to which they belong, and are the conditions under which the mixed population live equal to those of the two parental stocks? Without an answer to these questions, which require sociological knowledge, the biological inferences have little value (10).

Race. In the matter of physical anthropology in general and race in particular, the " . . . principal problems that must be taken up in a study of population . . . are (1) degree of homogeneity; (2) hereditary characteristics of existing lines; (3) influence of environment; and (4) influence of selection" (72).

As regards homogeneity, we have the important principle that "In . . . a homogeneous population of mixed descent we

may expect, on the whole, a high degree of variability in the family, while all the families will be more or less alike'' while '' . . . in a heterogeneous population in which each part is, comparatively speaking, 'pure', we may expect a low variability of each family with a higher variability of the families constituting the whole population'' (72).

As to hereditary characteristics of existing lines, it is noted that

> Racial heredity means that the typical distribution of forms of one generation will be repeated in the following generation. It has been recognized that differential birth rate, mortality and migration may modify the frequency of various types, but insufficient stress has been laid on the question in how far the children of parents of a given form may differ for physiological reasons from their parents, in other words, in how far external conditions may modify the type. We know that lower organisms are susceptible to such changes, but there is still considerable reluctance to accept this problem as one of major importance (11).

Also, the need for genetic study of single traits was stressed, for ''Whether or not the classical ratios of Mendelian inheritance prevail (in various characters) is a question . . . On the whole, it seems much more likely that we have varying types of alternating inheritance than true Mendelian forms'' (69).

Some indication of the possible significance of environment and selection in determining local types, as developed by Professor Boas, has been noted in the preceding. His position in the matter could scarcely be more succinctly or better put than the following passage (72):

> Since we recognize the influence of environment upon the form of body including such features as bulk of body, or muscular forms and the functioning of organs, it seems justifiable to define racial characteristics as we do those of a variable plant, namely, by stating that under definite environmental conditions the bodily form of a race and its functioning are such as we observe, without prejudging the question in how far modifications in form and function may result from changing environment. The actual problem, then would be to determine whether and how the traits of the body may be so influenced.

Apropos "type" or racial classification, Boas emphasized that

> The attempts of certain anthropologists to analyze on the basis of measurements and observations a population and to discover the constituent races is, at present at least, a hopeless task. Without the most detailed knowledge of the laws of heredity of each feature considered, as well as of the effects of environment, the task is like that of a mathematician who tries to solve without any further data a single equation with a large number of unknown quantities (72).

Also in the same paper he notes that classifications "made on the basis of a selected number of traits, like those of Deniker and many others, have an interest from a purely statistical point of view, showing how certain traits are distributed, but they do not give us any right to differentiate between racial strains."

Race and mentality. The relationship between race and mentality received early and repeated attention in the career of Professor Boas. In sum, his position was that functional phenomena

> . . . are, to a certain extent, determined by structure, but they vary in the same individual according to conditions, so that in a large population, containing many hereditary lines, similar outer conditions may produce functional similarities that may give the impression of being determined by racial descent, while actually they are due to similar conditioning. The interpretation of such phenomena requires the greatest caution, on account of the constant danger of considering as causally related anatomical and functional characteristics that are only accidentally related. This is particularly true of the attempts to correlate mental characteristics of populations and bodily form (10).

Also, "The genetic lines composing a race are so varied that the assumption that all members are by heredity endowed with the same physiological and mental characteristics is as absurd as to claim that they are all physically alike" (172).

Growth and development. Professor Boas repeatedly emphasized the need for including the children in any study of the physical type of a population or group. Thus,

Familiarity with the bodily forms of children is necessary also from a morphological point of view . . . [and] . . . a knowledge of the specialized (adult) forms ought to include a study of progressive differentiation. Particularly for the study of the influence of environment it is indispensable that the development of the body in childhood should be studied while the influences are still at work. We have to know the conditions which bring about retardation or acceleration in the development of various parts of the body and their ultimate effects upon the human form. The same is true with regard to selection. If selection is related to bodily form, it will probably act with particular intensity during the early years of childhood. It might be revealed by a comparison of the surviving and dying parts of the population of various ages (72).

Almost 20 years later, in 1941, he felt that

It is not possible at the present time to study the reaction of a given anatomical type to various environmental conditions, and there is little hope that the problem can be solved by this method. It seems more promising to study the interrelation between tempo and rates of growth and development of various parts of the body, because these will determine the ultimate proportions of the adult. The investigations of constitution and of the effects of internal secretion upon growth indicate where we have to look for modification of bodily proportions (172).

The citizen. Anthropology was not a field of mere esoteric interest to Professor Boas. On the contrary, he repeatedly and forthrightly spelled out how anthropology held forth profoundly practical lessons for our own society. His views on this score are perhaps best summarized in The Mind of Primitive Man (94) and Anthropology and Modern Life (103). Yet Professor Boas did not confine himself to the pages of scholarly journals or books, but applied his vast learning to combatting perversions of the truth, as he saw it, through the media of popular journals, letters to the editor of newspapers, in public address, and the like. That the anthropologist should participate actively as a citizen in the affairs of the day, utilizing his special knowledge for the common good, was a matter of principle with him, so well expressed in a passage of a radio broadcast made near the end of his life (191):

The ice-cold flame of the passion for seeking the truth for truth's sake must be kept burning, and can be kept alive only if we continue to seek the truth for truth's sake. But a new duty arises. No longer can we keep the search for truth a privilege of the scientist. We must do our share in the task of weaning the people from a complacent yielding to prejudice and help them to understand the problems that confront all of us.

Even a mere perusal of the works of Professor Boas in the appended bibliography cannot but deeply impress the reader with his greatness as a scientist and as a man. There is every reason to believe, as Professor Herskovits has pointed out ('43, p. 51), that the methods and problems elaborated by Boas will play an increasing and vital role in a dynamic development of physical anthropology in the years to come.

I am grateful to Dr. Gabriel Lasker for sending me pertinent data anent the relations of the late Professor Boas to the American Association of Physical Anthropologists; to Dr. T. Dale Stewart for helpful suggestions in the organization of the paper; and to Prof. Melville J. Herskovits for generously going over and commenting on the manuscript.

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THE CEREBRAL CORTEX OF PRIMATES.— The human cortex shows obviously a somewhat more elaborate pattern than that of the macaque. What is much more impressive, however, is the great similarity in cortical organization between macaque and man, at least as far as that organization can be recognized anatomically. It confirms the concept of a common primate pattern, advanced recently by Bonin (1945) . . .

The thesis of a common primate pattern . . . might be elaborated further. It is of interest to discover the homologue of Broca's speech area even in so lowly a form as the macaque, with its rather limited register of vocal expressions, and one might doubt whether homologizing what was called *FCBm* in the macaque with the area bearing that symbol in man is justified. Their histological structure is different, although no more so than would be expected from the difference in cell density. But histological structure is no absolute criterion for homology, which should, for any area, rather be sought in its connections, its topological relations as well as its structural resemblance, to other cortical areas . . .

Other elaborations might be made. But we would rather postpone a systematic survey for the future when the half of the cortex which is buried in the sulci has been explored physiologically and the cortex of the chimpanzee, and, we hope, the human cortex, has been studied more thoroughly.

Our principal aim in this monograph has been the description of the cortex of *Macaca mulatta.* For a discussion of the primate cortex in general, the time is not yet ripe. Gerhardt von Bonin and Percival Bailey. The neocortex of *Macaca mulatta.* Illinois Monogr. in Med. Sci., vol. 5, no. 4, 1947, xi + 100 pp. + 62 plates.

HEAD-BINDING IN THE NEAR EAST.—Head-binding is widely practiced in the Near East: I heard of it in Southern Greece at Chalcis and Patras and in the heroic district of Mani at the tip of the Peloponnese; among the two very different groups of Greeks who formerly lived respectively at Trebizond and Panderma in Asia Minor, but are now scattered over Greece since they came there as refugees in the 1920's; and among the Vlachs of Poroi in East Macedonia. It is not restricted to Greeks or possibly Hellenized Vlachs, but is usual among Turks. So I was informed by natives of Rodosto in Thrace and by the 'Konia' Turks of Western Macedonia, who have the longest, if not the purest, pedigree of all known Turks; they came from Konia in Asia Minor at the end of the fourteenth century and lived isolated in Macedonia until 1924, when they were returned to their country of origin under the scheme for the Exchange of Populations between Greece and Turkey.

In most cases only one bandage is employed. This is tied straight round the head above the eyes, tightly or loosely according as the midwife's hand is heavy or light; her views on the proper shape for the infant's head are also important, as are those of the women of the family. It is recognized that between them they may deform the head, without meaning to, by excessive zeal. With each race the bandaging aims deliberately at an aesthetic result. The Greeks and Vlachs, who like round heads, wish to make the head a little rounder. The Konia Turks, whose heads are naturally on the massive side, desire, as they said, 'to flatten the forehead' and 'to make the head high and flat instead of *tumba* (round).' The Albanians, who also dislike 'heads like apples,' do not need to bandage the heads of their babies because they achieve the flat effect of their admiration by strapping the infants to a board, which will be described in a later article.

Macedonian Greeks seldom keep the bandage on for more than a week. If ever they untie it before its final removal, they retie it in the same manner, sometimes altering the tension by accident or design. Southern Greeks keep it on from 3 to 10 days at the midwife's option, and Konia Turks for 40 days.

Macedonian Greeks, Poroi Vlachs and Konia Turks sometimes use a second bandage, tying this under the chin and over the crown, much as we tie up a dead person's head. Without the bandage the child's mouth might hang open, say the Greeks. The Vlachs use it to shorten a baby's face that seems over long, and the Turks to reduce a big chin and to push forward a retreating one. This bandage is optional, the first is indispensable. — Margaret Hasluck. Head-deformation in the Near East. Man, vol. 47, no. 143, October, 1947, pp. 130–131.

THE RELATION IN SIZE BETWEEN PREMAXILLA, DIASTEMA AND CANINE

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FOUR FIGURES

A gap in the upper dental row between the lateral incisor and the canine is commonly regarded as being directly and necessarily connected with the existence of large canines, the lower ones fitting into this gap, known as premaxillary diastema. This diastema has greatly gained in interest through some recent discoveries of fossil primates. From the presence or absence of a diastema in fossil fragments of jaws it is tempting to draw conclusions in regard to the size of the canines, if these should be missing. Any such conclusions, however, are at best hazardous, as will be apparent from these notes which are concerned with the following 3 questions: (1) Is the presence of a premaxillary diastema always associated with large canines? (2) Is the absence of a diastema connected with comparatively small canines? (3) What factors influence the formation of a diastema?

In many carnivores there exists a premaxillary diastema which accommodates the large lower canines when interlocked with the upper ones, precisely as in so many primates. This diastema, however, is found even if no lower canine fits into it, as happens in several breeds of domestic dogs. In English bulldogs, e.g., the mandible protrudes to such a degree that the lower canines reach in front of the upper incisors, yet the premaxillary diastema is usually well developed and this even though the upper premolars and molars

are extremely crowded. Such a case is shown in figure 1 and other, similar cases can be seen, e.g., among the many photographs of dog skulls in the monograph by Stockard and Johnson ('41).

In the writer's collection there is the skull of an adult female chimpanzee from Liberia in which the lower left second premolar is congenitally lacking and the lower left canine interlocks *behind* the corresponding upper canine (see figure 2, *C*). The premaxillary diastema in this skull measures

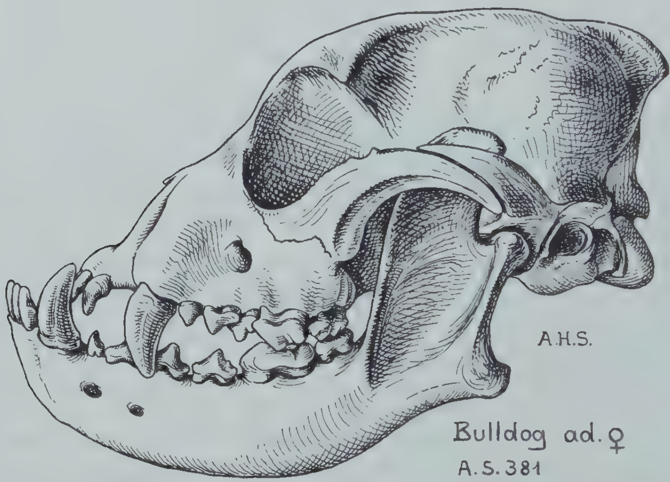

Fig. 1 Skull of an adult female English bulldog with extreme malocclusion and well developed premaxillary diastema.

7.3 mm even though it is not reached by the lower canine in occlusion. In man this diastema is not unknown, but is of course never needed by the lower canine. In an adult female Negro with perfect dentition, shown in figure 2, *D*, the premaxillary diastema measures 3.8 mm and the upper canines and all 4 incisors are of normal size. Schwarz ('25) has pictured the dentitions of 2 adult Melanesians with premaxillary diastemata 4 mm in diameter and mentions a third, very similar case in another Melanesian. Smaller diastemata, of only 1.5 to 2 mm, are not very rare in man, having been

found, e.g., in 2.4% of Chilean Indians (Ribeck, '36). These observations suffice to answer the first of the above-named 3 questions by stating that the existence of a premaxillary diastema is not necessarily an indication of large canines, since such diastemata can develop without any relation to the lower canines or in connection with only small canines.

In many primates with large upper and lower canines the premaxillary diastemata can be very small or even entirely lacking. For instance, in the gibbon and the baboon, shown in

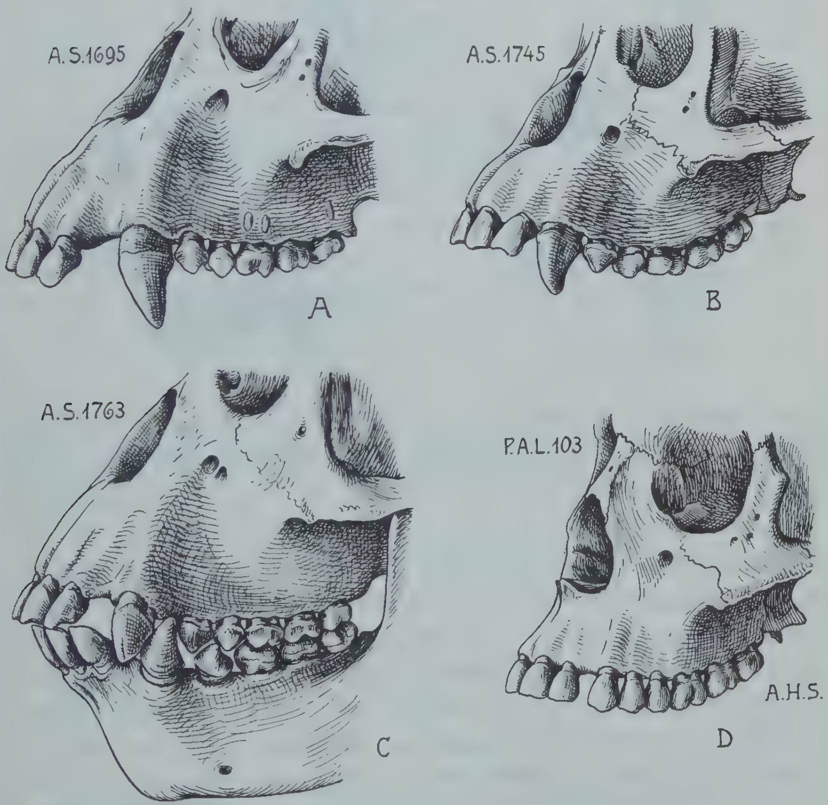

Fig. 2 Sketches of jaws of *A* adult male chimpanzee with large diastema and large premaxilla, *B* adult female chimpanzee with very small diastema and small premaxilla, *C* adult female chimpanzee with diastema, congenital lack of lower second premolar and lower canine occluding behind upper one, *D* adult female Negro with diastema.

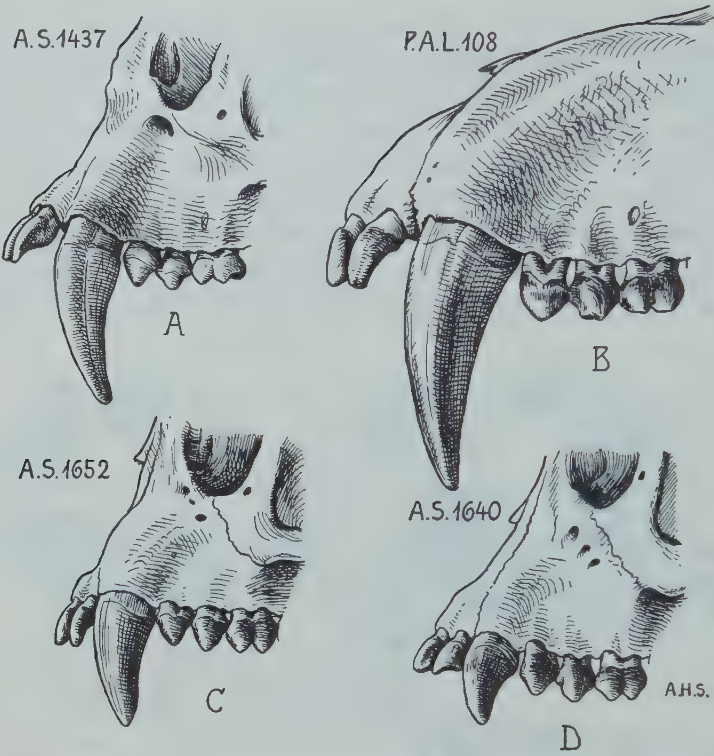

Fig. 3 Sketches of premaxillary region and upper canine in *A* female *Hylobates gabrielli*, *B* male *Papio sphinx*, *C* male *Semnopithecus cristatus*, *D* female *Nasalis larvatus*. All specimens are adult and wild-shot. *A* and *B* have very small diastemata, *C* and *D* have none.

figure 3, *A* and *B*, the diastema is extremely small in proportion to the huge canines.[1] In a chimpanzee from Sierra Leone, illustrated in figure 2, *B*, the diastemata are also too small to accommodate the large lower canines, if these had grown toward the exact location of the narrow upper diastemata. Among adult skulls, belonging to the subfamily Semnopithecinae, one encounters frequently specimens without any premaxillary diastemata, even though they possess very large canines. Two such cases are shown in figure 3, *C* and *D*. When-

[1] In these and all other specimens discussed here the size of the lower canines stands in the usual, close relation to the size of the upper ones and no exception needs to be specifically recorded.

TABLE 1

*The size (in mm) of the premaxillary diastema in adult great apes according to various authors (D = diastema; * = one side only; ** = both sides).*

PRIMATE	SEX	TOTAL OF *D*	AUTHOR	AVER.	RANGE	NUMBER OF *D* BELOW 2
		167**	Remane, '21	6.3	1–16	6**
Gorilla	♂	77**	Montagu, '43	6.2	1–14	2**
		25*	Schultz	6.7	2–13	0*
		76**	Remane, '21	4.9	1–10	6**
Gorilla	♀	57**	Montagu, '43	5.0	1–12	5**
		10*	Schultz	5.4	2–10	0*
		55**	Remane, '21	4.3	1–11	9**
Chimpanzee	♂	33**	Montagu, '43	5.4	1–9	2**
		15*	Schultz	5.7	0–11	1*
		65**	Remane, '21	5.0	1–10	3**
Chimpanzee	♀	56**	Montagu, '43	5.6	0–9	2**
		10*	Schultz	5.3	2–10	0*
		50*	Selenka, 1898	6.6	2–11	0*
Orang-utan	♂	49**	Remane, '21	6.2	0–11	4**
		44**	Montagu, '43	6.4	2–10	0**
		50*	Selenka, 1898	3.0	0–7	15*
Orang-utan	♀	33**	Remane, '21	4.2	0–9	4**
		34**	Montagu, '43	4.3	0–10	10**

ever large lower canines are combined with small or absent upper diastemata these teeth tend to diverge vertically so that in occlusion the tips of the crowns do not approach the alveolar process between the upper lateral incisors and canines. This outward growth of the lower canines represents undoubtedly a direct mechanical consequence of the lack of adequate upper diastemata.

In adult great apes the premaxillary diastema varies extensively in size, as shown by the data [2] compiled in table 1.

[2] It seems certain that each of the authors listed had made use of different series of skulls and that, hence, no specimens figure more than once in this table. Selenka and Remane have recorded only the numbers of cases in which a diastema measured between 1 and 2 mm, 2 and 3 mm, 3 and 4 mm, etc. From these data the writer has calculated averages by substituting the means of the group limits, i.e., 1.5 mm, 2.5 mm, 3.5 mm, etc. Remane and Montagu have measured the right and the left diastemata, whereever possible, so that their "Totals of *D*" represent about twice the number of skulls examined.

The total range lies between 0 and 16 mm. Any diastema less than 2 mm in length can not be regarded as significant in adult apes in view of the fact that many adjoining alveoli of other teeth are very commonly separated by interalveolar septa at least 1 to 2 mm thick, and not infrequently even thicker. The last column of table 1 gives the numbers of diastemata measuring less than 2 mm. The latter, in percentage of the total number of the diastemata examined, equal 3.0 in male gorillas, 7.7 in female gorillas, 11.7 in male chimpanzees, 3.8 in female chimpanzees, 2.8 in male orang-utans, and 24.8 in female orang-utans. In at least 4 instances among gorillas, 4 among chimpanzees and 29 among orang-utans the space between the upper canines and lateral incisors measures even only 1 or less than 1 mm and, hence, there is certainly no real diastema by any sensible definition.

The above facts give ample support for the conclusion that a premaxillary diastema can be lacking, or be merely diminutive, even though the canines are of large size.

In an attempt to find factors correlated with the size of the premaxillary diastema the following measurements were taken on 60 skulls of adult gorillas and chimpanzees in the writer's laboratory: (1) Inferior premaxillary length = from prosthion to aboral edge of incisive foramen in midsagittal plane. (2) Superior premaxillary length = from prosthion to lower edge of nasal aperture in midsagittal plane, at the highest point, behind which the premaxilla bends down toward the floor of the nasal cavity, at least lateral to the nasal septum. (3) Mean premaxillary length = arithmetic mean of measurements 1 and 2 (*MPm* in the tables 2 to 5). (4) Diastema length = smallest distance between margins of alveoli for right upper canine and lateral incisor (*D* in the tables). (5) Canine thickness = greatest diameter of alveolus for right upper canine in approximately sagittal direction (*C* in the tables). (6) Palate length (Maxilloalveolar length) = from prosthion to middle of line connecting aboral ends of upper alveolar processes (alveolon). In anthropoids the

latter point is generally preferable to the variable staphylion. (P in the tables.)

The measurements 3 to 6, the sum of diastema length and canine thickness, and the percentage relation between mean

TABLE 2

Data for 25 adult male gorillas, arranged according to increasing mean premaxillary length (= MPm) (D = length of diastema; C = diameter of canine; P = length of palate).

No.	MPm	D	C	$D+C$	P	$\frac{100\,MPm}{P}$
1	26	4	19	23	100	26.0
2	26	4	19	23	97	26.8
3	28	3	19	22	100	28.0
4	30	7	19	26	111	27.0
5	30	8	19	27	102	29.4
6	30.5	5	21	26	111	27.5
7	30.5	5	21	26	102	29.9
8	31	5	21	26	114	27.2
9	32	9	18	27	112	28.6
10	32	2	22	24	104	30.7
11	33	13	18	31	112	29.4
12	33	5	22	27	105	31.4
13	33.5	5	22	27	108	31.0
14	33.5	8	21	29	110	30.5
15	33.5	9	20	29	103	32.5
16	34	5	20	25	106	32.1
17	34.5	7	21	28	113	30.5
18	34.5	5	23	28	107	32.2
19	34.5	7	22	29	114	30.3
20	34.5	6	25	31	110	31.4
21	35	8	19	27	109	32.1
22	35	10	18	28	108	32.4
23	35.5	7	22	29	105	33.8
24	36	9	24	33	116	31.0
25	36.5	12	21	33	110	33.2
Average	32.5	6.7	20.6	27.4	107.6	30.2

premaxillary length and palate length are listed in the tables 2 to 5 in the order of increasing mean premaxillary length within each series. From an examination of the third and fourth columns in the tables it appears that the sizes of the

TABLE 3

Data for 10 adult female gorillas (arrangement and abbreviations explained in title of table 1).

No.	*MPm*	*D*	*C*	*D + C*	*P*	$\frac{100\ MPm}{P}$
26	23	2	14	16	84	27.4
27	24	6	12	18	85	28.2
28	25	3	15	18	89	28.1
29	25.5	3	14	17	87	29.3
30	26.5	7	12	19	91	29.1
31	29	4	13	17	85	34.1
32	29.5	5	15	20	92	32.1
33	30	5	15	20	91	33.0
34	30	9	11	20	91	33.0
35	32	10	13	23	94	34.0
Average	27.4	5.4	13.4	18.8	88.9	30.8

TABLE 4

Data for 15 adult male chimpanzees (no. 36 is a ''pygmy'' chimpanzee).

No.	*MPm*	*D*	*C*	*D + C*	*P*	$\frac{100\ MPm}{P}$
36	19	3	11	14	62	30.6
37	23	3	14	17	71	32.4
38	23.5	6	13	19	74	31.7
39	24.5	0	16	16	72	34.0
40	24.5	5	15	20	76	32.2
41	25.5	5	15	20	75	34.0
42	26.5	3	14	17	72	36.8
43	27	3	15	18	71	38.0
44	27	4	17	21	76	35.5
45	28	5	17	22	81	34.6
46	29	9	12	21	76	38.1
47	30	9	14	23	79	37.9
48	32	9	17	26	85	37.6
49	34	10	16	26	83	40.9
50	35.5	11	15	26	84	42.2
Average	27.3	5.7	14.7	20.4	75.8	35.8

diastema and of the canine vary quite independently of one another. Plus variations in one measurement combine with plus variations in the other, or minus variations in the one with minus variations in the other in only 11 of the 35 gorillas and in only 8 of the 25 chimpanzees, whereas in the remaining two-thirds of the cases plus variations of the diastema coincide with minus variations of the canine and vice versa. In male gorillas, e.g., the most slender canine, only 18 mm thick, is found in the specimen with the maximum diastema length of 13 mm and the thickest canine, measuring 25 mm, belongs

TABLE 5

Data for 10 adult female chimpanzees.

No.	*MPm*	*D*	*C*	*D + C*	*P*	$\frac{100\,MPm}{P}$
51	21	2	10	12	66	31.8
52	21.5	4	11	15	71	30.3
53	22.5	2	11	13	68	33.1
54	25	6	9	15	69	36.2
55	26	4	11	15	73	35.6
56	27.5	5	12	17	76	36.1
57	27.5	10	10	20	78	35.3
58	28	9	10	19	78	35.9
59	29	5	13	18	75	38.7
60	30.5	6	13	19	78	39.1
Average	25.8	5.3	11.0	16.3	73.4	35.2

to a skull with a diastema of only 6 mm. The correlation coefficient and its probable error for the diameters of the diastema and of the canine amounts to -0.26 ± 0.13 in the series of male gorillas, to -0.63 ± 0.13 in the series of female gorillas, to $+0.02 \pm 0.17$ in the series of male chimpanzees, and to -0.19 ± 0.20 in the series of female chimpanzees. These figures also support the conclusion that there is either no relation between the size of the diastema and that of the canine, or else this relation can be inverse.

Inasmuch as the upper diastema is largely or entirely formed by the premaxilla, it seems promising to investigate

the possibility of a relation between diastema length and the mean premaxillary length. The size of the premaxilla varies extensively in the great apes, especially in male chimpanzees among which the premaxilla can occasionally protrude to a surprising degree, forming a huge shelf (e.g., figure 2, *A*). The great individual differences in the size of the premaxilla of gorillas and chimpanzees are readily seen from the exact drawings in figure 4 which also indicate a positive correlation between premaxillary size and diastema length. In absolute size the mean premaxillary length ranges from 26 to 36.5 mm in male gorillas and from 19 to 35.5 mm in male chimpanzees. The variation coefficient for this measurement amounts to 8.74 ± 0.84 in the former and to 15.42 ± 1.04 in the latter. The total length of the palate (*P*) is not nearly as variable as the mean premaxillary length. The variation coefficient for the palate length amounts to only 4.57 ± 0.44 in male gorillas and to 7.69 ± 0.94 in male chimpanzees. That the variations in premaxillary length are by no means simply due to variations in the length of the entire palate, is also evident from comparisons between the columns for *MPm* and for *P* in the tables 2 to 5. The last column in all 4 of these tables demonstrates that in general the larger the absolute size of the mean premaxillary length the greater is its percentage relation to the total length of the palate. For instance, among male chimpanzees the mean premaxillary length equals only 30.6% of the palate length in the specimen with the smallest absolute size of the premaxilla, whereas 42.2% in the skull with the maximum absolute premaxillary length (table 4, see also figure 4). From this it can be concluded that the premaxilla in at least gorillas and chimpanzees can grow with a surprising degree of independence, become overdeveloped in some specimens and, by contrast, remaining underdeveloped in others.

Fig. 4 Midsagittal sections of palates with projected outlines of upper lateral incisor and canine in adult gorillas, chimpanzees and Negroes, all reduced the same amount. The inferior and superior premaxillary lengths determine the extent of the shaded area of the premaxilla. The numbers refer to the serial numbers of the specimens, as listed in the tables 2 to 5.

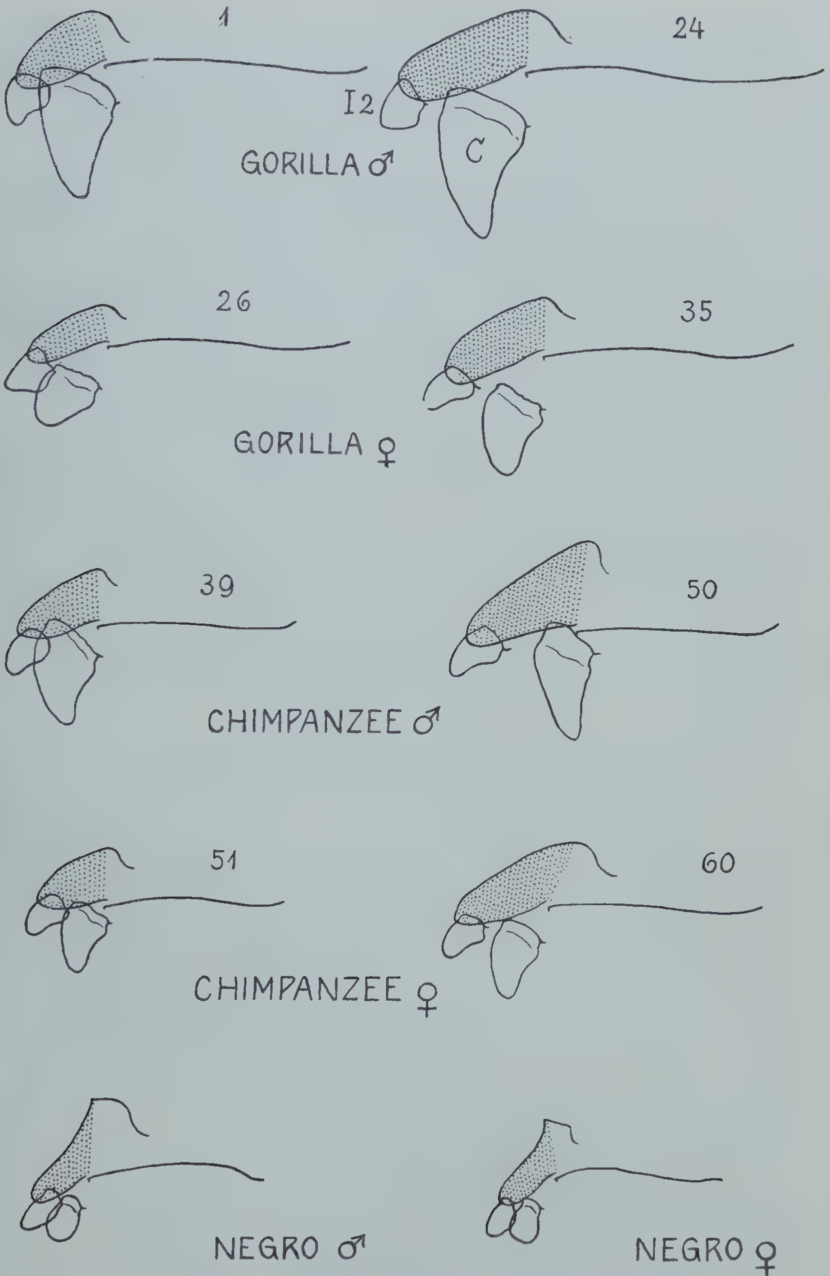
1
24
I2
C
GORILLA ♂
26
35
GORILLA ♀
39
50
CHIMPANZEE ♂
51
60
CHIMPANZEE ♀
NEGRO ♂
NEGRO ♀

Figure 4

By comparing the second and third columns in the tables 2 to 5 it is found that in general the diastema length tends to be larger in the lower half of the column, than in the upper half, and, since all the specimens are tabulated by increasing premaxillary length, this measurement, naturally, is also larger in the lower half of the column than in the upper half. The averages of the diastema length amount to 5.8 for the first 12 male gorillas, whereas to 7.5 for the following 13 male gorillas. The corresponding averages equal 4.2 for the first 5 female gorillas and 6.6 for the second 5, 3.6 for the first 7 male chimpanzees and 7.5 for the remaining 8, and 3.6 for the first 5 female chimpanzees and 7.0 for the second 5. The correlation coefficient for diastema length and mean premaxillary length amounts to $+0.53 \pm 0.10$ in the series of male gorillas, to $+0.67 \pm 0.11$ in the series of female gorillas, to $+0.79 \pm 0.06$ in the series of male chimpanzees, and to $+0.64 \pm 0.13$ in the series of female chimpanzees. These findings demonstrate that in the African apes the size of the upper diastema is directly influenced by the length of the premaxilla, but only to a limited degree.

As has been shown above, an unusually large canine can encroach on the adjoining diastema and reduce its length, or the latter can become increased in size by being associated with an exceptionally slender canine. For these reasons it can be expected that the total space between the upper lateral incisor and first premolar should be less variable in size than the diastema alone. These combined measurements for diastema length and canine thickness ($D + C$) are listed in the fifth columns of the tables 2 to 5. The variation coefficients, based on these data, amount to 10.18 ± 0.97 in the series of male gorillas and to 17.74 ± 1.09 in the series of male chimpanzees. Both these values lie far below the variation coefficients for the diastema length alone which equal in the same 2 series 39.10 ± 2.43 and 54.74 ± 5.36 respectively. By comparing the data for the combined diastema length and canine thickness in the fifth column with those for the mean premaxillary length in the second column in each of the

tables 2 to 5, one recognizes readily that there exists a close general correlation between these 2 measurements. A few marked exceptions are found, as e.g. in the gorilla no. 11 which has a very large $D + C$ measurement, though its premaxillary length is only average. This exceptional combination is chiefly due to the fact that the upper lateral incisors of this specimen are unusually small and that, consequently, the diastemata have become much enlarged and this in a transverse, rather than sagittal, direction. In man the well-known and comparatively frequent reduction in size of the upper lateral incisors, and especially the total congenital absence of these teeth, produces at times a marked premaxillary diastema. Such a case has been illustrated in a former paper by the author ('34, fig. 1).

The correlation coefficient for the mean premaxillary length and the combined diastema length and canine thickness equals $+ 0.79 \pm 0.05$ in the series of male gorillas, $+ 0.81 \pm 0.07$ in the series of female gorillas, $+ 0.91 \pm 0.03$ in the series of male chimpanzees, and $+ 0.87 \pm 0.05$ in the series of female chimpanzees. All these values speak for a very significant correlation between the 2 measurements under consideration. It can be concluded, therefore, that intragenerically the distance between the upper lateral incisor and first premolar is primarily determined by the growth of the premaxilla which, if intense, carries the incisors away from the premolars and, if negligible, retains the incisors in close proximity to the premolars (see fig. 4). Of this space between lateral incisor and first premolar the upper permanent canine occupies a part dependent upon the thickness of this tooth, leaving the varying remainder as the diastema.

In attempting to find the cause underlying the remarkable variations in the size of the premaxilla among great apes, it is obvious to think of the premaxillary sutures, especially their facial portions, and of the great individual differences in the ages at which these sutures become obliterated. The well-known, very early disappearance of any facial separation between premaxilla and maxilla in man may be connected

with the lack of striking variations in size of the premaxilla in recent man. As shown by table 6, the facial portions of the premaxillary sutures of chimpanzees begin to obliterate regularly at their lower ends, but this obliteration progresses upward at a highly variable rate, being already complete in 2 infants, whereas still incomplete in 5 adults. Remane ('27), Ashley-Montagu ('35), and others have found a very high intrageneric variability of the age at which these sutures become closed in chimpanzees as well as in the other anthropoids. It seems quite possible that the size of the premaxilla is influenced by the age of obliteration of the premaxillary sutures. Such a relation, however, could be satisfactorily

TABLE 6

Obliteration of the facial portions of the premaxillary sutures in chimpanzees according to the author's records.

AGE	SPECIMENS	NONE	LOWEST $\frac{1}{4}$	LOWER $\frac{1}{2}$	LOWEST $\frac{3}{4}$	COMPLETE
Fetal	3	1	1	1	..	..
Infantile	18	..	4	6	6	2
Juven. I	22	..	1	5	9	7
Juven. II	26	..	..	6	8	12
Adult	66	.	..	1	4	61

proved only by means of repeated x-ray photographs of living, growing animals. It is certain that the premaxilla can increase in size even after at least the alveolar portions of the premaxillary sutures have disappeared and that the growth of the premaxilla can continue to the very end of the period of dental eruption, especially in the primates with late, full development of their large canines. In male gorillas, e.g., the space between the upper lateral incisor and first premolar increases rapidly and intensively while the deciduous canines are being replaced by the permanent ones. In 4 late-juvenile, male gorillas, lacking only their third molars and canines, this space ($D + c$) averages only 15.7 mm or less than the average canine thickness (20.6 mm) of adults. During

the eruption of the huge permanent canines the alveolar portions of the premaxillary sutures become pushed forward and the diastemata are either encroached upon or else are also carried forward.

SUMMARY

Premaxillary diastemata are not necessarily related to large lower canines which require these gaps in the upper row of teeth. Such diastemata exist in certain breeds of dogs without relation to the mandibular canines, they have been found in human dentitions with their small canines and in a chimpanzee in which the lower canine interlocks behind the upper one.

Premaxillary diastemata can be extremely small or entirely lacking in numerous primates with large canines. If measuring less than 2 mm, these diastemata have no real significance. Such undeveloped or absent diastemata are common in Semnopithecinae and have been found among adults of all the great apes with percentage frequencies reaching 11.7 in male chimpanzees and 24.8 in female orang-utans.

With detailed measurements on the palates of 4 small series of adult male and female gorillas and chimpanzees the following results have been obtained: There is either no correlation, or else a tendency for an inverse relation, between the size of the premaxillary diastema and that of the (upper) canines, the relevant correlation coefficients varying between $+0.02$ and -0.63 in the series used. The length of the premaxilla varies very extensively in the great apes and more than the length of the palate. In percentage of the latter measurement the former amounts to anywhere between 26 and 34 in male gorillas and between 31 and 42 in male chimpanzees, the proportionately largest premaxillas being generally also the absolutely largest ones and vice versa. The length of the upper diastema is fairly closely related to the length of the premaxilla, as shown by the corresponding correlation coefficients which vary between $+0.53$ and $+0.79$ in the series examined. This correlation would

be more pronounced, were it not for the fact that the diastema length can have a limited inverse relation to the variable thickness of the canines. For this reason these 2 measurements were added to represent the total space between the upper lateral incisor and first premolar. The latter measurement is intragenerically very closely dependent upon the length of the premaxilla. The correlation coefficients, expressing this relation, fluctuate in the 4 series between + 0.79 and + 0.91. It is evident that the size of the upper diastema together with the space occupied by the upper canines are closely determined by the very variable, sagittal development of the premaxilla.

The remarkable independence in growth of the premaxilla in at least the African apes is possibly connected with the very high intrageneric variability of the ages at which the premaxillary sutures become closed.

In view of these findings it appears particularly desirable to learn more of the detailed formation of the premaxillary region in those fossil primates which may bridge the gap between recent apes and man.

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GRANTS FOR RESEARCH PROJECTS.— Grants-in-aid for research have been made by the U. S. Public Health Service recently as follow:

To Dr. A. H. Washburn, Director, Child Research Council, Denver, Colorado, for "The study of the significance of individual differences in growing human beings." This is to cover periodic observations of physical, physiological, psychological and sociological aspects of growth in each of 130 children, starting at birth.

To Dr. Reidar F. Sognnaes, Assistant Professor, Harvard University Dental School, for studies in "Dental paleopathology." It is intended to investigate by a new method the histological structure of prehistoric and ancient teeth in order to determine whether certain structural properties are associated with such (presumably caries resistant) teeth.

To Dr. Allan G. Brodie, Head, Department of Orthodontia, University of Illinois, for "Cephalometric x-ray study of the growth of the human head from the 8th to the 15th year." This will permit the continuation of work begun 15 years ago on the growth of the human head from the 3rd month of life.

To Dr. Nancy Bayley, Research Associate, Institute of Child Welfare, Berkeley, California, for "Developing new x-ray standards for assessing skeletal development." It is proposed to develop a new set of standards of skeletal maturity which are independent of chronological age, but spaced in objective and approximately equal units of degree of skeletal maturity.

To Dr. Steven O. Schwartz, Director, Hematology Laboratory, Hektoen Institute for Medical Research of the Cook County Hospital, Chicago, for study of "Sicklemia; question of hemolytic process in latent forms." The problem of sicklemia is considered important if its transmission is dominant, as is generally accepted, since it is theoretically possible that in time 75% of all Negroes will have the trait.

European Isophons Follow the Isogenes.— The group expresses its genetic character in dialect. . . .

The crucial importance of dialect for the genetic understanding of language is seen where a single standard language has been imposed by a single political and cultural agency on a people sharply divided genetically into two groups. Most European countries provide examples but the French division is best documented. The transition between southern and northern dialects, is, as in England, a gradual one, but, according to Meillet, if a boundary is drawn it has to run from Lyons to Bordeaux, not directly, but skirting the northern edge of the central massif. What does this speech boundary mean? It has been a cultural or political barrier at various times, in the days of the Langue d'Oc and of the Albigenses as well as of Vichy, but always as a result of invasions from beyond the Rhine. Although submerged by the political power, at one time of Rome, at another of Paris, it is the natural boundary between a fixed native population and one which has been subject to mixture with northern invaders. It is a genetic boundary. . . .

The European sound complement varies most clearly, and the history of the variation can be traced most accurately, in respect of the TH sound. I therefore propose to use it as a pilot test and to illustrate methods and principles.

. . . The value of TH in this consideration is merely that the European populations are mostly close to the threshold which divides its expression from its suppression and are consequently apt to change from one to the other under influence of migration and conquest. It can therefore be used as a marker to indicate *gradients* in the population of the whole continent through its frequency, its existence as a phoneme, and its time of origin or extinction. Such gradients correspond to the *clines* which genetics recognises as characteristic of the natural geographical populations of polymorphic species. We have therefore to discover whether, on independent evidence, any other clines can be mapped for man in the region we are considering.

. . . When I began my enquiries no such characters were sufficiently known in man. Adaptive clines like those for pigmentation in Europe are obvious enough. Others, too, like that for colour-blindness (Vernon and Straker, 1943), may have an adaptive taint. Now, however, in the blood groups we are beginning to have what we want.

. . . The O and TH maps agree more closely than the apparently confused history of Europe would seem to justify us in predicting. The *isogens* are almost exactly equatable with the *isophons*. C. D. Darlington. The genetic component of language. Heredity, vol. 1, no. 3, 1947, pp. 269–286.

OCCIPITAL FLATTENING AMONG THE DINARICS

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This paper is intended as a brief statement of our present views relating to occipital flattening as a diagnostic of the Dinaric race and as a summary account of the processes by which we arrived at them.

The material analyzed consists of a series of 851 individuals measured in Montenegro by Ehrich in 1932 and 1076 inhabitants of North Albania measured by Coon in 1929–1930. The monographs dealing with these series are now in the final stages of preparation and are scheduled to appear shortly as Peabody Museum Papers.

In our original drafts we both accepted the Dinaric racial type, as conventionally described, to be a reality, and we attempted to achieve a more precise definition, description, and historical explanation. Further, as suggested by Bunak ('27) and developed by Hughes ('38) in his study of Armenians, and by Coon ('39) in his *Races of Europe,* both of us treated the Dinarics as a blend of disharmonic physical types, and we considered occipital flattening as a natural concomitant of such a mixture.

Coon's original manuscript on the Albanians was prepared in 1932, and Ehrich presented his analysis of the Montenegrin series as a doctoral dissertation in the spring of 1946. During that summer Ehrich was engaged in preparing his paper for publication.

In the fall of that year, Father John F. Ewing informed us that he found a striking difference between the cephalic index of native born and American born Lebanese Maronites, and that this difference coincided with the tying down of the child

and the use of the cradleboard in the Lebanon and with the absence of these practices among the American born sample. Stimulated by these findings, we reassessed our own material in order to test whether the implications of Father Ewing's work were applicable to the Dinaric type as found in Montenegro and Albania, where cradleboards are also used. References to artificial deformation so produced occur in the Yugoslav literature (Filipović, '35; Hasluck, '47; Trojanović, '27). At the meetings of the American Association of Physical Anthropologists, December 1947, Father Ewing and Ehrich read papers on the subject, and in the spring of that year Father Ewing submitted his interpretation in a doctoral dissertation. His final manuscript for publication is still in preparation.

At the present time the writers would question the existence of a distinct Dinaric (or Armenoid) racial type as conventionally defined. The crux of the matter lies in whether occipital flattening is always inherited or whether it can be the result of an artificial deformation either intentionally or unintentionally produced. Since a flattened occiput is correlated with both hyperbrachycephaly and hypsicephaly, and since all 3 characters are major diagnostics in the identification of both Dinarics and Armenoids, this question is of fundamental importance.

The considerations which lead to our conclusion can be summarized briefly.

1. In his original analysis Ehrich made a sorting by morphological types. Subgroups representing predominantly Dinaric, Alpine, Mediterranean, and Nordic elements, and others composed of their recognizable crosses were segregated. The anthropometric data for each group were seriated and compared with the other subgroups by means of the formula $\frac{d}{\sqrt{\text{p.e.M.}_1^2 + \text{p.e.M.}_2^2}}$. When an xpe value of 3 was taken as the measure of significant difference, it was found that if "Dinaric" was regarded as denoting a predominantly rugged Mediterranean type with artificial occipital flattening, all subgroups classed as having a "Dinaric" component, when com-

pared with other subgroups which would then be of equivalent composition, showed striking differences in head length, head breadth, and head height, and in the indices in which these measurements were incorporated. Other measurements and indices of the face and body, however, showed relatively few differences as compared to the marked divergence shown between groups of markedly different composition. Thus while apart from the skull, the differences between Dinarics and Mediterraneans and between Dinaric-Alpine and Alpine-Mediterranean crosses were relatively slight, those between Alpine and Mediterranean for example, were numerous and marked.

2. A subgroup of 97 Montenegrins selected by the criterion of *pronounced* occipital flattening, when compared with the total Montenegrin series, showed relatively shorter and broader faces and noses. This not only suggests a deviation from the original concept of a Dinaric type, but it also suggests a greater proportion of Alpinoid facial characters associated with pronounced flattening. In our interpretation we feel that it is logical to suppose that a round-headed stock would normally exhibit a more marked degree of artificial flattening than would a group characterized by a projecting occiput.

3. Coon has divided his total series of Albanians into 2 subgroups, 330 with occipital flattening and 737 without it. When these 2 subgroups were seriated, the means for the flattened and unflattened individuals within each series were found to be virtually identical in all measurements and indices except for head length, head breadth, head height, and dependent indices. Furthermore, flattened and unflattened subgroups fail to differ in hair form and distribution, or in pigmentation. In variability the measurements and indices of the cranial vault are likewise abnormal. In Coon's series the cephalic index rises progressively with the degree of flattening. Ehrich divided his Montenegrin series into similar subgroups, of 385 with occipital flattening and 466 without it, and obtained the same general results.

4. An anthropometric study of South Albanian Toscs resident in the Boston area (begun in 1947 and still in progress) by Mr. William Laughlin and Mr. David DeHarport of Harvard [1] shows that although this group is essentially Alpine in composition, it exhibits a marked degree of occipital flattening. Also, parallelling Father Ewing's Maronite findings, this character is much less frequent among the subjects born in this country. This observation seems to hold true even within family groups.

The key inference of this study is that the human skull is a great deal more plastic than many physical anthropologists have realized, and that this plasticity must be taken into account in the evaluation of anthropometric data. The critical factor in the production of occipital flattening and hyperbrachycephaly would seem to lie not so much in the use of the cradle board itself or in deliberate deformation, as *in the length of time that the infant's head remains relatively immobile.*

It seems perfectly possible that occasionally some degree of flattening can occur through genetic mechanisms but without reference to any specific racial group. Where flattening is found to be characteristic of a population, as among the Dinarics and Armenoids, it not only crosscuts recognizable racial subgroups, but it also coincides with cradling practices known to be associated with artificial deformation.

If we accept this interpretation, we must redefine our concept of Dinarics and Armenoids. The basic conclusion advanced by Bunak ('27), Hughes ('38), Coon ('39), and Khérumian ('43) that "Dinaric and Armenoid" populations represent a disharmonic blend of diverse dolichocephalic and brachycephalic elements is perfectly tenable. The rather marked degree of diversity found within isolated groups is easily attributable to an incomplete fusion of the elements in the blend, and the diversity between areas to differences in the proportions of the basic components.

[1] The writers participated briefly in their work and are citing their own impressions with Mr. Laughlin's and Mr. DeHarport's generous permission.

The characteristic skull form can then range from high mesocephaly to moderate brachycephaly, with occipital flattening and hyperbrachycephaly dropped from consideration. A high correlation between the degree of occipital flattening and the degree of brachycephaly appears strikingly in Coon's series of North Albanians and is parallelled to a lesser extent (due to a less strict evaluation of the degree of flattening) in Ehrich's Montenegrin series. Khérumian also reports a relationship between occipital flattening and brachycephaly among his Armenians. It should be further noted that in all 3 series some individuals with cephalic indices in the lower ranges also exhibit a flattened occiput.

The writers are perfectly aware that it is possible to find an explanation at variance with their own for each specific point mentioned. It seems to them, however, that when all the approaches are taken into consideration, the evidence is overwhelming and points inescapably in only one direction.

SUMMARY

In the Dinaric area, and particularly in Montenegro and Albania, occipital flattening is one of the principal physical characteristics of the local population. It is a diagnostic of the Dinaric race. Statistical analysis of 2 large anthropometric series shows that this flattening is an independent variable, without relationship to any "racial" characters outside the cranial vault, or to any such combination of characters. Occipital flattening affects the length, breadth, and height dimensions of the head, and the dependent indices. It appears to be responsible for cases of extreme brachycephaly in these series. In Montenegro and Albania, as in the Lebanon and elsewhere, occipital flattening can be shown to be, in most cases at least, the result of local cradling practices. It is thus an environmental character. While one cannot exclude the possibility of its occurrence genetically, one cannot at the same time apply the name Dinaric and Armenoid, as heretofore defined, to races in the genetic sense; most Dinarics and Armenoids exist only as phenotypes.

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THE PACIFIC SCIENCE ASSOCIATION has accepted the invitation of the Royal Society of New Zealand to hold the Seventh Pacific Congress in New Zealand in 1949. The forthcoming Congress has the same scope and purpose as those previously held: Honolulu (1920), Sydney and Melbourne (1923), Tokyo and Kyoto (1926), Batavia and Bandoeng (1929), Vancouver and Victoria (1933), and Berkeley, Stanford and San Francisco (1939).

The Royal Society of New Zealand has appointed an Organizing Committee charged with the general arrangements for the Congress, with responsibility for perfecting the programme and for local arrangements in Auckland and Christchurch.

In general the programme will follow the lines of previous Congresses, and it will be arranged as a series of symposia. . .

Attention will be focused on those subjects of Pacific scope which, while possessing a vital interest for Pacific peoples, press for immediate action. The subjects of symposia have been chosen so as not to conflict with, although they may supplement, the topics to be dealt with by Standing Committees [one of which is the Committee on Blood Groups of which Dr. H. L. Shapiro is Chairman]. — Preliminary announcement, April, 1948.

ON THE RELATION BETWEEN AGE OF MOTHER AND PERCENTAGE OF STILLBIRTH IN THE TOTAL, THE "WHITE" AND THE "COLORED" U. S. POPULATIONS

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ONE FIGURE

INTRODUCTION AND DATA

A relation between age of mother and percentage of stillbirth in man has been indicated by the studies of Ewart ('11), Gini ('13), Holmes ('21), Taussig ('36), Pearl ('33), and others. No detailed statistical examination of the question, however, has been made. Accordingly, it seems desirable to present an extensive set of data pertaining to this problem and to apply to them such statistical tests as seem appropriate.

The raw data which we are presenting are numbers of all births and of stillbirths taken from the yearly reports of the United States Bureau of the Census. They represent the 15-year interval from 1922 to 1936, inclusive. The ages of mother which are considered cover the entire reproductive span of the human female, but are grouped into 9 5-year periods as follows: 10–14, 15–19, 20–24, 25–29, 35–39, 40–44, 45–49 and 50–54.

The procedure which we have followed has been to calculate the percentage of stillbirth for each of the 9 age groups of mother for each of the 15 years, and to obtain from these distributions a mean percentage of stillbirth for each age group. It is these means which we shall consider as representative

of the different age groups. They are listed in table 1 and graphically represented in figure 1. It should be pointed out that only those live- and stillbirths for which sex is recorded are included. Sex is recorded in the census records for all live births but not quite for all of the stillbirths.

From an inspection of table 1 and of figure 1, it may be seen that the mean percentage of stillbirth for the youngest age group of mother (10–14) in the total population is 6.70, and that those for succeeding age groups decrease gradually

TABLE 1

The means of 15 yearly percentages of stillbirths (sex known) for 9 different age groups of mother in the total U. S. population, 1922–1936, inclusive.

AGE GROUP	TOTAL LIVE- AND STILLBIRTHS COMBINED	NO. OF STILLBIRTHS	MEAN PERCENTAGE STILLBIRTH
10–14	37,663	2,502	6.70
15–19	3,639,829	142,958	3.93
20–24	9,177,407	280,643	3.06
25–29	8,171,776	245,241	3.00
30–34	5,615,423	197,260	3.51
35–39	3,516,069	162,211	4.61
40–44	119,511	70,756	6.01
45–49	117,072	9,161	7.80
50–54	2,408	197	8.09
Total	30,397,158	1,110,929	3.60

up to age group 25–29, and then increase gradually to the highest level of 8.09% at the close of the reproductive period of the human female.

In order to comment in precise terms regarding the observed differences, it is of interest to determine the probability of these differences. This can be done by applying the standard formula for a test of the significance of the difference between 2 means.

$$t = \frac{\Delta}{\sqrt{\frac{\Sigma (X_1 - \overline{X}_1)^2 + \Sigma (X_2 - \overline{X}_2)^2}{N_1 + N_2 - 2} \times \frac{N_1 + N_2}{N_1 N_2}}}$$

All of these comparisons which are made allow 28 degrees of freedom. Therefore, an observed "t" value of 2 or more has a probability of .05 or less and may be considered indicative of a statistically significant difference.

In table 2 are presented the "t" values obtained by comparing the means of the percentages of stillbirth of all of the different age groups. From an examination of this table, it may be seen that nearly all of the differences between the means of successive age groups, up to age group 45–49, are highly significant. The lack of significance between the means of age group 45–49 and 50–54 appears to be due only to lack of large numbers. (From an examination of table 1 it may be seen that the number of all births which occurs in the last age group is very small.)

TABLE 2

The "t" values obtained from a comparison of the percentage means of stillbirths of the different age groups of mother in the total U. S. population, 1922 to 1936 inclusive.

AGE GROUPS COMPARED [1]	DIFFERENCE BETWEEN MEANS	"t" VALUE
10–14 vs 15–19	2.768	15.7
15–19 vs 20–24	0.870	12.3
20–24 vs 25–29	0.059	1.2
25–29 vs 30–34	0.509	11.5
30–34 vs 35–39	1.098	21.0
35–39 vs 40–44	1.396	12.8
40–44 vs 45–49	1.794	12.3
45–49 vs 50–54	0.288	0.6
10–14 vs 50–54	1.389	2.6

[1] The larger mean is underscored.

When the mean of the youngest age group of mother is compared with that of the oldest, it is found that the latter is significantly higher. In other words, although the percentage of stillbirth is high for young mothers, it is even higher for mothers at the end of the female reproductive span.

Before discussing some of the possible reasons for the observed significant differences in percentage of stillbirth for different age groups of mother, we wish to examine, as we have above for the total U. S. population, certain subgroups

of the total population. The U. S. Census records do not permit us to consider all racial groups separately, but they do allow us to examine data of what are called by the Bureau of the Census the "white" and the "colored" U. S. populations. The "white" population probably includes only members of the Caucasoid stock. The "colored," on the other hand, includes all members of the Negroid and Mongoloid stocks, and also some Caucasoid. Although the latter is true, it seems probable that about 95% of what is called the "colored" population is of Negroid stock. The data for the "colored" population may, therefore, be considered fairly representative of the U. S. Negro population. In this connection, we must point out that after we had made our analysis of the total population based on the stillbirth numbers for which sex was recorded, we found that the census records do not give all of the corresponding data for the "white" and the "colored" populations considered separately. The total birth data (live and stillbirth combined) and the stillbirth data for these 2 populations include sex-unknown stillbirths as well as those for which sex was recorded. The difference in the type of data used is, however, a relatively insignificant one and does not prevent valid comparisons and valid conclusions from being drawn.

The mean percentage of stillbirth for the different ages of mother within the "white" and the "colored" populations considered separately are presented in tables 3 and 4, respectively. The same percentages are shown graphically in figure 1.

An examination of tables 3 and 4 and of figure 1 shows that the same trend, in percentage of stillbirth with respect to age group of mother, which was indicated for the total population, is followed by both the "white" and the "colored" populations. It will be apparent, however, that each of the mean percentage of stillbirth for the "colored" population is considerably higher than each of the corresponding means for the "white." Whether or not these differences are statistically

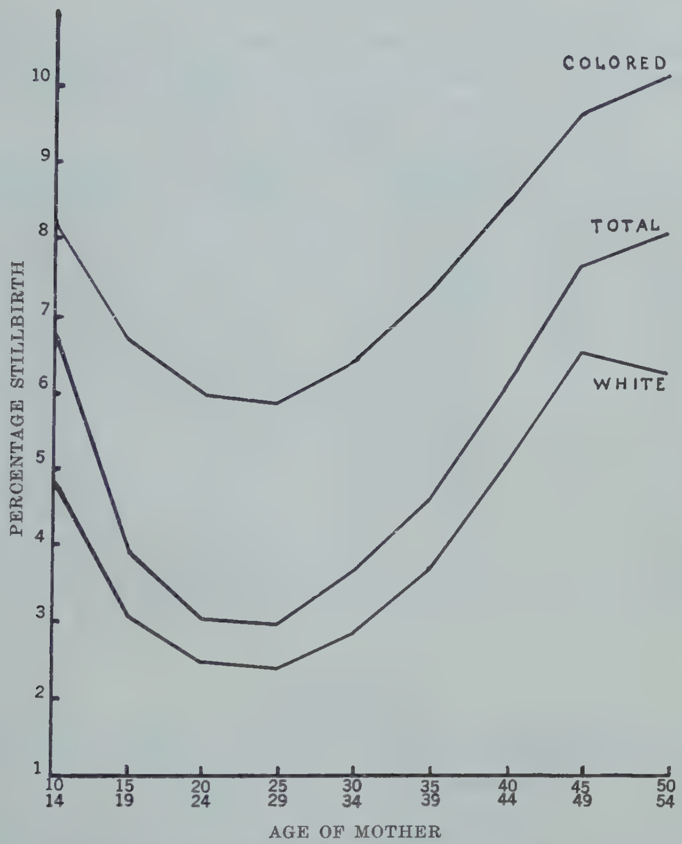

Fig. 1 The percentage of stillbirth for each group of mothers within the total, the "white" and the "colored" U. S. populations for 1922–36, inclusive. The calculations are based on about 30 million births.

significant can be ascertained by applying the same formula as was applied in the earlier comparisons. The "t" values obtained are listed in table 5. An examination of this table shows that all of the means for the different age group of mother of the "colored" population are significantly higher than the corresponding ones for the "white." This is true even of the 2 means of the last age group within which the numbers are small for both populations.

TABLE 3

The means of the 15 yearly percentages of stillbirth (sex known and unknown) for 9 different age groups of mother in the "white" U. S. population, 1922 to 1936 inclusive.

AGE GROUP	TOTAL LIVE- AND STILLBIRTHS COMBINED	NO. OF STILLBIRTHS	MEAN PERCENTAGE STILLBIRTH
10–14	16,575	780	4.76
15–19	2,932,379	88,350	3.03
20–24	8,044,321	193,623	2.42
25–29	7,386,585	177,348	2.40
30–34	5,124,016	147,482	2.88
35–39	3,174,291	122,319	3.86
40–44	1,088,272	55,865	5.15
45–49	101,306	6,952	6.86
50–54	1,687	113	6.56
Total	27,869,432	792,832	2.82

TABLE 4

The means of the 15 yearly percentages of stillbirth (sex known and unknown) for the 9 different age groups of mothers in the "colored" U. S. population, 1922 to 1936, inclusive.

AGE GROUP	TOTAL LIVE- AND STILLBIRTHS COMBINED	NO. OF STILLBIRTHS	MEAN PERCENTAGE STILLBIRTH
10–14	21,052	1,686	8.11
15–19	751,998	50,086	6.72
20–24	1,114,604	68,548	6.17
25–29	763,049	45,751	6.00
30–34	471,733	30,104	6.40
35–39	325,896	24,060	7.39
40–44	100,250	8,303	8.31
45–49	15,014	1,457	9.64
50–54	663	65	10.12
Total	3,564,258	230,060	6.51

TABLE 5

Table of "t" values obtained from comparisons of the mean percentage of stillbirth for each age group of mother within the "white" U. S. population with the corresponding percentages for the "colored" U. S. population (1922–1936 inclusive).

AGE GROUP WHITE VS COLORED [1]	DIFFERENCE BETWEEN MEANS	"t" VALUE
10–14	3.35	33.3
15–19	3.69	78.0
20–24	3.75	102.9
25–29	3.60	114.4
30–34	3.51	100.8
35–39	3.53	90.9
40–44	3.16	65.4
45–49	2.78	30.7
50–54	3.56	8.0
All ages	3.69	96.3

[1] Each mean of the "colored" population is larger than the corresponding one of the "white."

DISCUSSION

We may turn now to a consideration of the causal factors which are responsible for the observed significant differences in percentage of stillbirth. Let us examine first of all the probable reasons for the higher percentage of stillbirth for very young mothers than for somewhat older ones. In his studies on guinea pigs, Wright ('26, '29, '34, '36) found a number of characteristics whose frequency of occurrence gave evidence of being influenced by the age of the dam. Among these characteristics he lists percentage of stillbirth, percentage of polydactyly, and percentage of white in white spotting. Wright attributes these differences, in part at least, to differences in competition between the growth processes of the dam and the developmental processes of the embryo. In other words he visualizes this competition as being high in young mothers and lower in older ones. It appears to us that part of the high percentage of stillbirth for young mothers which

we have observed in the human species may be due to this same type of competition. Certainly human mothers between the ages of 10 and 14 have not stopped growing and require considerable quantities of materials for their own developmental processes which might otherwise be available to the embryo. That an embryo may suffer from competition is suggested by the previous studies of Strandskov and Ondina ('47) in which it was found that the percentage of stillbirth increases significantly with each increase in number of embryos carried per pregnancy. The percentage of stillbirth for single births in the total U. S. population was found to be 3.50; whereas, those for twin, triplet, and quadruplet births were found to be 7.53, 14.28 and 19.92, respectively.

Although it appears probable that competition between mother and embryo may be partly responsible for the higher percentage of stillbirths for young mothers than for older ones up to the age group 25–29, we are of the opinion that an even greater share of it is due to the absence in the very young mother of a fully developed or fully functional endocrine system. We have in mind, in particular, the endocrines associated with implantation, maintenance of pregnancy and onset of parturition. Crew ('31) has stressed the fact which was known, but not always kept in mind by earlier investigators; namely, that puberty and maturity are not synonymous. He presented some new evidence in support of the view that the development of maturity is a long and gradual process and is not fully established before a considerable time has elapsed following the onset of the reproductive capability of the mammalian female. Price ('47) has reviewed and critically considered the studies which concern the causal factors involved in this gradual development of the reproductive system of the mammal. She emphasizes not only the gradual increase in levels of hormones, but also the gradual increase in the sensitivity of the organs which respond to these hormones.

A third factor which may be responsible for the higher percentage of stillbirths among young mothers than among older ones is the fact that most of the births reported for young

mothers are first births. Holmes ('21) has shown that first births, irrespective of age of mother, give slightly higher percentages of stillbirth than do second and third order births. This suggests that some adjustments occur in the female reproductive tract during the first pregnancy or first birth which insure a more successful subsequent pregnancy. However, it is clear that this factor is not the sole responsible cause for the higher percentage of stillbirth among young mothers, because he also found that the percentage of stillbirth among first births also decreases with age of mother up to a certain age level.

What the factors are which are responsible for the gradual increase in percentage of stillbirth with increase in age following the 25–29 age period is an even more unanswerable question at the present time. Pearl ('39) has shown that the percentage of abortion and miscarriage is lower for pregnancies 1 to 9 than for pregnancies 10 to 22. This suggests that something which may be called reproductive exhaustion is partly responsible. Although this may be true in part, it appears to us that an even more important factor is a gradual diminution in the functional state of the endocrine system of the human female and perhaps also a gradual diminution in the ability of the tissues and organs to respond. We must admit, however, that there exists very little specific information in the literature to support this point of view. Nevertheless, it appears probable on the basis of many general facts. Engle ('39) has reviewed and considered some of the experimental results which bear on this problem, but has drawn only a few conclusions which appear to be relevant to the question considered here.

At this point we should like to emphasize that although we have discussed more or less separately various factors which operate at a given moment in the age of a mother, we appreciate that these factors are not completely independent of one another, but that they are to some extent interrelated and interdependent.

The reasons for the observed racial differences in percentage of stillbirth are also difficult to establish. Wright ('29), Crew ('31), and others have presented evidence from studies on experimental animals which suggest that genetic factors can be responsible for differences in percentage of stillbirth. Furthermore, we are aware of a number of inherited human characteristics which might contribute to racial differences in this characteristic. Yet, we must admit that without more conclusive evidence in favor of hereditary factors, we are inclined to attribute most of the observed higher percentage of stillbirths within the "colored" U. S. population to general environmental factors rather than to hereditary ones.

In connection with this discussion of the relation between the age of mother and the percentage of stillbirth, it seems appropriate briefly to call attention to 2 other human characteristics which have not been mentioned so far but which have been shown to be influenced by age of mother. One of these is the occurrence of mongolism. A number of investigators have reported on this relation. The most critical analysis appears to be that of Penrose. He found ('33) that the mean age of mothers of 154 mongolian idiots was 39.4. This age of mother he found to be significantly higher than that of mothers of normal children. Another human characteristic which has been shown to be influenced by age of mother is the frequency of occurrence of plural births. Dahlberg ('26) has reviewed the literature on this subject and has presented some original data. He concludes that an increase in the frequency of plural birth does occur with age of mother. We are at present analyzing this question with respect to the U. S. population. Hence, we shall defer further comment until we have completed our analysis.

SUMMARY

1. The relation between age of mother and percentage of stillbirths is analyzed for the "total," the "colored" and the "white" U. S. populations.

2. It is found that the percentage of stillbirth in the total population is high for young mothers (6.70%), decreases gradually up to age group 25–29, and from there on rises gradually to the highest peak of all (8.09%) at the end of the reproductive span of the human female. Most of the differences between the percentages of stillbirth for the different age groups of mother are found to be statistically significant.

3. The probable responsible factors for the observed relation between age of mother and percentage of stillbirth are briefly discussed. It is concluded that the improper or incomplete functioning of the endocrine system of the young mother is probably the major responsible factor for the high percentage of stillbirths among young mothers. Likewise, it is concluded that the increase in percentage of stillbirth near the end of the reproductive span of the human female probably is due primarily to a gradual cessation of the proper functioning of the endocrine system.

4. It is found that the percentage of stillbirth for the "colored" U. S. population is significantly higher for each age group of mother than is the corresponding percentage within the "white" U. S. population.

5. This observed racial difference in percentage of stillbirth is suggested to be due primarily to variations in general environmental factors rather than to variations in heredity.

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"STRESSCOAT" STUDIES ON THE FEMUR.—"Stresscoat" is the trade name for a brittle lacquer which cracks in response to tension deformation occurring in the object upon which it is sprayed. The location and direction of the cracks mark points of weakness where failure would occur under sufficient load.

The results of the "stresscoat" studies [on human femora] clearly demonstrated that the bones failed (fractured) under tension stress.

Walmsley's opinion that, when standing erect with the knees and heels together, the lateral condyle is the greater weight-supporting condyle is substantiated.

Bones from individuals over 60 years of age supported a smaller load, before the appearance of cracks in the "stresscoat" lacquer, than did bones from persons less than 60 years of age.—F. G. Evans and H. R. Lissner. "Stresscoat" deformation studies of the femur under static vertical loading. Anat. Rec., vol. 100, no. 2, 1948, pp. 159–190.

SEX DIFFERENCES IN THE PUBIC BONE

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ONE FIGURE

The nature and degree of sexual differentiation in the pelvis has long been of interest to anatomists and anthropologists. It is of practical importance to obstetricians and to those who would identify skeletal remains. In spite of numerous efforts there still is no certain method of determining the sex of an individual skeleton. Hooton ('46) states that "the determination of the sex from the postcranial skeleton in adults is easy and certain in about 80% of cases, difficult but possible in another 10% of cases, and quite dubious in the remainder." It is the purpose of this paper to present a method of sexing skeletons which works in a greater percentage of cases.

During a study on the skeletal proportions of monkeys (Washburn, '42), the writer noticed that the pubic bones of the females were much longer than those of the males. In order to compare animals of varying size, an index was constructed by dividing the length of the ischium into the length of the pubic bone (Schultz, '30). The reason for using this proportion is that the difference in the length of the ischium is roughly proportional to the difference in size, but the pubic bone is proportionately longer in the female. In macaques (*Macaca irus*) the mean and range for this index are: adult males 84(80–93), adult females 105(97–116). There is no overlapping of the ranges, and the mean difference exceeds 20%. It was decided to investigate whether a disparity of this order exists in man.

MATERIALS AND METHODS

Measurements of the pubis and ischium were made on 300 adult skeletons of known race and sex from the collection of the Hamann Museum of Anatomy and Comparative Anthropology of Western Reserve University. The writer wishes to thank Dr. Normand L. Hoerr for permission to study this unique collection.

The technique of measurement used was that described by Schultz ('30). Length of ischium and pubis were measured from the point at which they meet in the acetabulum. This point can be identified approximately in the adult because: (1) frequently, there is an irregularity there, both in the acetabulum and inside the pelvis; (2) there is a change in thickness which may be seen by holding the bone up to a light; (3) often there is a notch in the border of the articular surface in the acetabulum. In measuring the pubis care should be taken to hold the caliper parallel to the long axis of the bone.

RESULTS

The measurements of pubis length, ischium length and the ischium-pubis index are listed in table 1, and the distribution of the index is shown graphically in figure 1. The table shows that the pubic bone is both absolutely and relatively longer in

TABLE 1

Length of pubis and ischium in mm and ischium-pubis index.

		PUBIS LENGTH				ISCHIUM LENGTH				ISCHIUM-PUBIS INDEX			
	No.	Mean	Range	S.D.	C.V.	Mean	Range	S.D.	C.V.	Mean	Range	S.D.	C.V.
White male	100	73.8	(65–83)	4.1	5.6	88.4	(75–98)	4.3	4.9	83.6	(73–94)	4.0	4.8
White female	100	77.9	(69–95)	4.4	5.6	78.3	(69–93)	3.8	4.9	99.5	(91–115)	5.1	5.1
Negro male	50	69.2	(60–88)	4.7	6.8	86.6	(79–96)	3.6	4.1	79.9	(71–88)	4.0	5.0
Negro female	50	73.5	(63–86)	4.4	6.0	77.5	(67–86)	4.4	5.7	95.0	(84–106)	4.6	4.8

females than in males. Only 5 white males are in the range of female variation. There is more overlapping in the case of the Negroes, probably as a result of race mixture. The pubic bone in the Negroes is shorter than in the Whites. This reduces the index so that there is considerable overlapping between white males and negro females. Males and females are equally variable.

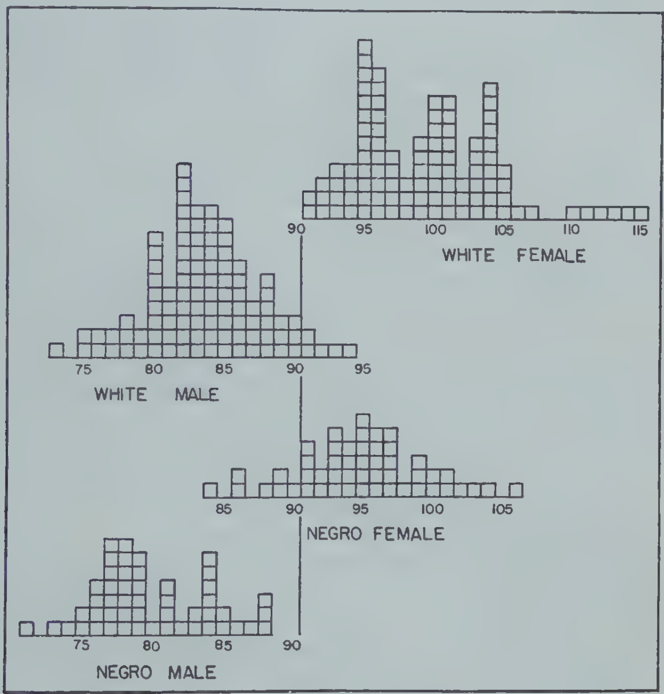

Fig. 1 The distribution of the ischium-pubis index in Whites and Negroes.

DISCUSSION

The ischium-pubis index alone will sex over 90% of skeletons, provided that they belong to one major racial group. If the mean difference in man (15%) was as large as in macaques (20%), there would be no overlapping of the ranges of males and females. The reduction in the mean difference is enough so that prediction of the sex of a human skeleton is not certain

in all cases, but the ischium-pubis index alone will sex skeletons with more certainty than all the traditional measurements, indices, and observations together.

Why such a simple proportion as the relation of the ischium to the pubis is an effective index of sexual differentiation needs examination. In the fetus (Thompson, 1899) and during the first year of life (Reynolds, '45) there is no sex difference in the length of the pubic bone. The pubic bone of both males and females is much shorter than the ischium, and the ischium-pubis index for both males and females averages 83% during the first year of life (index calculated from data in Reynolds, '45).

In males 3 to 7 years of age, the ischium-pubis index remains approximately the same (82–83%, calculated from Reynolds, '47). This is almost identical with the index of adult male Whites as determined in this study (83.6%). Since Reynolds measured the bone lengths on roentgenograms, there may well be differences in technique, and it is quite possible that small growth changes in the ischium-pubis index might appear if one technique could be followed throughout. However, it seems that, at most, there would be minor fluctuations. In infant, juvenile, and adult males the ischium and pubis bear the same relation to each other.

In females, 3 to 7 years of age, the ischium-pubis index averages approximately 85–86% (calculated from data in Reynolds '47). Here there is a departure from the infant relation, caused by the ischium being slightly shorter, and the pubis longer. However, the average difference between boys and girls is small (2% or 3%), and the childhood average falls far short of that of adult female Whites (99.5%). Sometime after 7 years of age, during a period when the ischium-pubis relations in the male remain constant, the index in the female increases 14%. The lowest values for adult female Whites (90%) exceed the childhood mean by at least 4%. The difference between juvenile and adult females is almost as great as between adult males and females.

Greulich and Thoms ('44) have shown that the pelvic inlet of females grows extremely rapidly for approximately 18 months at puberty. During this brief period the inlet loses the constricted outline characteristic of pre-adolescence and grows to typically female size and form. This change in shape is due to growth in the sacrum (Martin, '28), in the lower iliac height (Straus, '27), and in the pubic bone. All these are relatively larger in the female, but the difference is greatest in the case of the pubic bone. The excess of growth which characterizes these parts of the female pelvis at puberty has a hormonal basis (Greulich and Thoms, '44). This has been shown experimentally in sheep by Franz ('08). The pelvis of sheep from which the ovaries had been removed failed to develop female characters. On the other hand, the pelvis of the hypo-gonadal male is typically male (Greulich and Thoms, '39). The length of the pubic bone is the best indicator of the sex of a skeleton because it is the part which is most responsive to the action of female hormone.

Traditionally (Hooton, '46; Hrdlička, '39), the subpubic angle, height of the pubic symphysis, and shape of the obturator foramen have been used to differentiate the female pelvis. According to the view presented here, these are all secondary to the elongation of the pubic bone. As the bone grows longer, the subpubic angle must become wider, and, with less uniformity, the symphysis becomes shorter and the obturator foramen more triangular. The advantage of measuring the length of the pubic bone directly is that it gives an estimate of the primary variable, it is easier than measuring the angle, and one does not run the risk of counting the same difference over and over again in a variety of forms. Furthermore, it can be done on one innominate bone and does not necessitate articulating the pelvis. This avoids estimates of the amount of cartilage in the pubic symphysis, confusion arising from post-mortem changes, and is of special value to the archaeologist who must work with fragmentary material.

The length of the pubic bone enters into both the sagittal and transverse diameters of the pelvic inlet. In fact, it is the

part of the pelvis which, more than any other, causes the sex difference in these dimensions. Sexing pelves by measuring the diameters is less efficient than by measuring the pubic bone alone, because the other components of the diameters (lower ilium and sacrum) contain smaller sex differences than the pubic bone. Therefore, the diameters, or indices computed from them, will predict the sex of a pelvis with less certainty than the length of the pubic bone alone. A further difficulty with pelvis diameters, or their relations, is their high variability. It will be noted (table 1) that neither the length of the pubis or ischium, nor their relation, are unusually variable. However, both the length and breadth of the pelvic inlet and their relation (inlet index) are extremely variable (Howells and Hotelling, '36; Young and Ince, '40; Nicholson, '45). The coefficient of variation of the length of the pubic bone averages approximately 6, that for the conjugate diameter and inlet index 8 to 10 (Young and Ince, '40; Nicholson, '45). As the anatomical complexity increases, the variability increases. The pubic bone is a part of the pelvis which shows extreme sexual differentiation and which has a low variability compared to diameters or indices.

To increase the efficiency of the ischium-pubis index as a sex differentiator, it should be coupled with other characters which belong to completely different anatomical systems. The sciatic notch is larger in females than males, and has been shown to have no statistical correlation with the sub-pubic angle (Howells and Hotelling, '36; Young and Ince, '40). The independence of the notch may be demonstrated in other ways. It is larger in the female fetus (Thompson, 1899) and infant (Reynolds, '45, '47); and a large sex-difference is present before puberty (Greulich and Thoms, '47). While the sort of sex differences seen in the pelvic inlet of man are common to many mammals which have large young, only man has a well developed sciatic notch, and man is the only primate with a sex difference in the notch (Straus, '29). Statistics, growth, and comparative anatomy, all show that the sex difference in the sciatic notch belongs to a different system from that in the

pubic bone. In man, the decrease in length of the lower ilium and the development of the sciatic notch are part of the adaptation to bipedal locomotion on the ground (Weidenreich, '13). Decrease in the lower iliac height brings the sacrum posterior to the pubis and creates a true bony birth canal (Schultz, '30). This causes obstetrical complications, so that the basic adaptation to the erect posture had to be accomplished differently in the 2 sexes. The sciatic notch is not correlated with the subpubic angle, and has a different ontogenetic and evolutionary history. Therefore, it may be used with the ischium-pubis index as an additional indicator of sex difference. The sex of over 75% of pelves can be determined by the notch alone, therefore theoretically well over 95% of skeletons can be sexed, using the index and an observation on the notch. Actually, the sex of none of the 300 innominate bones studied at Western Reserve University was in doubt, using only these two criteria. Obviously, major racial groups must be treated separately.

The degree of protrusion of the sciatic spines into the pelvic outlet is a function of the width of the sciatic notch and the width of the sacrum. The sacro-spinous ligaments go straight from the ischium to the sacrum. The spines are in the same plane as the ligaments. Since both the width of the sacrum and the size of the notch have already been considered, observations on the spines would add nothing new.

Since absolute size bears no relation to the ischium-pubis index in this material and since the sex difference in the size of the ischium is pronounced, small ischia will tend to be female. Also, the greater size of the femoral heads (and hence acetabulae) in the males may be unrelated to the other characters. Size of ischia and acetabulae will afford additional evidence of sex in doubtful cases.

The purpose of this study has been to describe the sex difference in the length of the human pubic bone, and secondly, to develop a method of sexing skeletons. Yet, even the pursuit of these limited objectives involves a theory of pelvic form. According to the view presented here, sex differences in the subpubic angle, symphysis, obturator foramen, and parts of

both inlet diameters, are all aspects of the same thing — the late growth of the pubic bone. Late growth in the sacral width and lower ilium account for the remainder of the remodelling of the inlet and are also part of the hormone-mediated system of sex-differences. Both the evolutionary history and pattern of growth of the sciatic notch show that it belongs to a different system. The sex of a pelvis may be determined as surely by one measurement (or observation) from each system, as by a multiplicity of measurements and observations which describe the same fundamental differences over and over again.

SUMMARY

1. The length of pubis and ischium was measured on 300 human skeletons of known race and sex (100 white males, 100 white females, 50 negro males, 50 negro females).

2. The pubis is shorter in Negroes than in Whites.

3. The ischium-pubis index was calculated. It averages 15% higher in females than males, and the sex of over 90% of skeletons can be determined by this index alone, provided major racial groups are treated separately.

4. The size of the subpubic angle and many other characters which distinguish the female pelvis are dependent on the pubic bone.

5. The sex difference in the sciatic notch belongs to an entirely different anatomical system. If it is combined with the ischium-pubis index, the sex of the vast majority of skeletons can be determined.

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PEABODY MUSEUM ALEUTIAN EXPEDITION.— The Peabody Museum of Harvard University plans to send an expedition to the Aleutian Islands for a period of approximately 3 months during the summer of 1948 to conduct medical and anthropological studies of the Aleuts.

The object of the research is to look for physical and cultural adaptations made in answer to the demands of their particular environment. It is planned to study, among other things: Blood groups, including AOB, MN, and the Rh divisions; caries and occlusion; composition of the teeth (analysis to be made in Boston); chlorosterol level; cardiovascular studies (blood pressure, heart rate, heart sounds; systolic/diastolic pressure; effort tests; serum proteins, fats, haemocrit, prothrombin time); assay of all ingested foods and analysis — amino acids, etc.; saliva (analysis for tryptophane and tyrosine and correlations with caries); basal metabolism; anthropometry; somato-

types; visual field; and Rorschach, thematic aperception and Horn-Hellersberg tests.

In addition to blood groups of the skeletons, skeletal pathologies will be studied and any changes or selection in blood groups, dental caries, etc., will be determined.

The procedure will be to go to the village of Nikolski and begin the study of the inhabitants and the excavation of the deep site there. Then the expedition will go to other villages to study the living and to investigate other promising archeological sites.

The field personnel will be composed of 7 men: William S. Laughlin (director), Stanley M. Garn and Charles I. Shade (physical anthropologists), F. Alexander (cardiologist), Coenraad F. A. Moorrees (orthodontist), Alan G. May (archeologist), and Gordon C. Marsh (linguist).

LATEST U. S. POPULATION FORECASTS.— The Bureau of the Census released on March 22, 1948, its publication "Forecasts of the population of the United States, 1945–1975."

The author of these latest forecasts is Prof. P. K. Whelpton, associate director of the Scripps Foundation for Research in Population Problems. He was assisted by Drs. Hope T. Eldridge and Jacob S. Siegel, of the Bureau of the Census.

This is a detailed and comprehensive study of many aspects of population growth in the United States and deserves careful study by the American people. It can be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., price 45 cents.

According to these forecasts, the total population of the United States will increase from 145,000,000 on January 1, 1948, to about 166,000,000 in 1975, and will become still larger thereafter. This is a "medium" forecast, and assumes "medium" decreases in birth and death rates and a net immigration of 100,000 persons per year.

When no immigration between 1945 and 1975 is assumed, the population is estimated to reach 162,337,000 in 1975 and a maximum of 165,276,000 about 1990. Then it is estimated that the population will slowly decrease.

Whether these forecasts will fit the facts of future increase, will remain to be seen. It is quite possible that the Pearl forecast of 180,437,000 for 1990 will be nearer the census count for that year. But from a consideration of what would be better for the Nation, the Whelpton estimate of 165,276,000 would seem to be nearer the desired result. — Guy Irving Burch. Speculations in population growth. Population Bull., vol. 4, no. 2, May, 1948, pp. 9–13.

"ANTERIOR" AND "POSTERIOR" MEDIO-PALATINE BONES

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FIFTEEN FIGURES

Medio-palatine bones are among the rarest of cranial anomalies (Stieda, 1894; Le Double, '06; Augier, '31; Ashley-Montagu, '40). Calori in 1868 first mentioned 2 small bones situated in the center of the cruciate suture of the hard palate and called them "Ossa Wormiani medio-palatini od inter-palatini." Later (1892) he found another case in which the bones occupied the length of the palate from the incisive foramen to the transverse palatine sutures. Adachi ('00) reported 1 case in 328 Japanese skulls. Giuffrida-Ruggeri ('01) observed 1 example and Vram ('03) reported another, of which the bone on the right side was bipartite. Recently 1 more case of medic-palatine bones has been described by Ashley-Montagu ('40). Thus far, there are 6 cases of complete medio-palatine bones clearly recorded. In addition, as Ashley-Montagu ('40) has noted in his thorough review of the literature, Zona ('35) mentions having observed an isolated bony element at about the center of the medio-palatine or interpalatine portion of the palate in 57 of 998 adult Italian skulls. A more detailed report is needed to justify their grouping with the 6 cases definitely identified as complete medio-palatine bones.

Portions of lateral longitudinal palatine sutures suggesting medio-palatine bones have been recorded by a few authors. Referring to the work of Calori, Stieda (1891, p. 8) wrote:

Der Calori'sche Nahtknochen kommt offenbar sehr selten vor: unter allen Schädeln, die ich untersuchen konnte, fand ich keinen Schädel mit der betreffenden Anomalie. Nur ein einziges Mal habe ich eine unvollständige Verschmelzung der Nahtknochen mit dem Oberkiefer gesehen. So deute ich wenigstens eine kleine 4 mm messende Nahtlinie in den Processus palatini des Oberkiefers, die an einem Schädel rechts deutlich links undeutlich sichtbar war.

Later (1894) Killermann reported 4 cases and Adachi ('00) 9 cases of traces of the sutures. Matiegka in 1900 made a detailed study of the hard palate utilizing a series of 416 adult skulls. He failed to find a single example of complete mediopalatine bones, but mentioned 15 cases having incomplete lateral longitudinal palatine sutures.[1] Le Double ('06) found them in 21 of 512 skulls of natives of Touraine, France. Frédéric ('09) reported the presence of these sutures in 2 Alsatian skulls.

A lateral longitudinal suture in the horizontal part of the palate bone also is rarely encountered. When present it demarcates a separate bone in the posterior part of the palate adjacent to the median palatine suture. Hyrtl (1862, p. 419) first reported this condition:

Wir fanden nämlich die Pars palatina des rechten Gaumenbeines durch eine sagittale Naht getheilt, welche mit dem Längenschenkel der Sutura cruciata parallel zog, und die zwei inneren Drittel der horizontalen Gaumenbeinplatten zu einem selbstständigen Knochen erhob, welcher natürlich seinen besonderen Ossificationspunkt gehabt haben musste.

Later Adachi ('00) mentioned 4 cases each with 1 such suture. The only reference found in the literature to this condition in

[1] Matiegka mentioned separately 12 cases with portions of lateral longitudinal palatine sutures coursing forward from the transverse palatine sutures and 6 cases with traces of the sutures coursing backward from the incisive sutures; however, 3 of the 6 cases also had sutures extending from the transverse palatine sutures. In considering that the 3 cases were included among the 12 cases, the present writer concludes that the total is 15. Le Double ('06, p. 247) cited Matiegka as having observed 18 cases of this variation and Augier ('31, p. 420) referring to Le Double's book credits Matiegka with 31 cases. The reason for the former discrepancy is obvious, whereas the latter would be difficult to explain.

the fetus was made by Frassetto ('08), who noticed on a fetal cranium of 5 months a sagittal suture dividing the horizontal part of the palate bone into 2 equal parts.

The present writer has studied the hard palate in 1548 skulls (675 American Whites, of which 539 were males and 136 females; 873 American Negroes, 571 males and 302 females) in the Terry Anatomical Collection of Washington University.

OBSERVATIONS

Two cases of complete medio-palatine bones were found. One is in skull no. 1433R, a White female, age 78 (figs. 1 and 2). The other is in skull no. 148, a Negro male, age 13 (figs. 3 and 4).

The first case has bones similar in shape to those which Calori found in 1892. The outline of the bones when viewed together is roughly rhomboidal, extending from the incisive sutures to the transverse palatine sutures with a length of 23 mm on the right side and 22 mm on the left side. The maximum breadth of each bone is 7 mm. The surface of the palatine vault is fairly smooth, arched a little upward. All the teeth had been lost and the alveolar processes showed marked resorption with only the socket of the left second incisor remaining.

The medio-palatine bones of the second case are much smaller, situated at the antero-medial part, instead of the postero-medial part as in the first case of Calori, of the palatine processes of the maxillae, and their contour is also different from that described by Calori. These bones are roughly rectangular, occupying a length of 10 mm on the right side and 9.5 mm on the left side. The maximum breadth of the right bone is 3 mm; of the left, 4 mm. The surface of the palatine vault is uneven and highly arched. All of the permanent teeth are present; the third molars on both sides are still within their crypts, though with the crowns well exposed. All the teeth are in good condition.

Besides the 2 cases of complete medio-palatine bones, 17 cases with portions of lateral longitudinal palatine sutures

indicating the presence of incomplete medio-palatine bones were found among the 1548 skulls. These ranged from cases of almost complete bones to those so reduced as to be indicated only by mere traces of lateral longitudinal palatine sutures. Two of them (Negro male, age 58; White female, age 67) are nearly complete, in which cases more than three-fourths of the delimiting sutures are present (fig. 5). Three cases (White male, age 69; White female, age 78; Negro male, age 26) have more than one-half and less than three-fourths of the full extent of the sutures present (fig. 6). Four cases (2 White males, age 57 and 78, respectively, and 2 Negro males, age 28 and 60, respectively) have more than one-fourth and less than one-half of the sutures present (fig. 7). The remaining 8 cases (4 Whites, 2 males and 2 females, age 58–70; 4 Negroes, 3 males and 1 female, age 26–81) have only traces of lateral longitudinal palatine sutures present or less than one-fourth of the delimiting sutures (fig. 8). It is interesting to note that the incidence of the variation was highest when the extent of the sutures was most reduced (table 1). All the incomplete examples suggest that the bones extend from the incisive sutures to the transverse palatine sutures with 1 exception (skull no. 498, White male, age 78) which has its lateral longitudinal palatine sutures extending antero-laterally from the posterior one-third of the palatine processes of the maxillae as shown in figure 9.

TABLE 1

Incidence of complete, partial and mere traces of lateral longitudinal sutures in the palatine processes of the maxillae in 1548 skulls.

STATE OF SUTURES	CASES	RACE				SEX			
		White (675)		Negro (873)		Male (1110)		Female (438)	
		Cases	%	Cases	%	Cases	%	Cases	%
Complete	2	1	.15	1	.11	1	.09	1	.23
Partial[1] ($\frac{3}{4}$–)	2	1	.15	1	.11	1	.09	1	.23
Partial ($\frac{1}{2}$–$\frac{3}{4}$)	3	2	.30	1	.11	2	.18	1	.23
Partial ($\frac{1}{4}$–$\frac{1}{2}$)	4	2	.30	2	.23	4	.36	0	0
Mere traces (–$\frac{1}{4}$)	8	4	.59	4	.46	6	.54	2	.46

[1] Partial sutures have been classified according to their extent.

Six cases of lateral longitudinal sutures in the horizontal parts of the palate bones were found in this series of 1548 skulls. These sutures extend in a sagittal plane between the transverse suture of the palate and the posterior margin of the horizontal process of the palate bone and thus run more or less parallel to the median palatine suture. Thus, such a suture forms a boundary of another anomalous palatal bone related to the horizontal process of the palate bone rather than to the palatine process of the maxilla. In 2 cases (Negro male, age 51; White male, age 64) the anomalous bones are bilateral since the sutures are present on both sides (figs. 10–13). In 4 cases the anomaly is unilateral: 3 of these (2 White males, age 65 and 66, respectively and 1 Negro female, age 43) have the lateral longitudinal suture on the right side only (fig. 14), one of which terminated before reaching the transverse palatine suture and the bone is therefore incomplete; the remaining case (Negro male, age 52) has a lateral longitudinal suture on the left palate bone only (fig. 15). In table 2 these findings are summarized according to race and sex. The lateral longitudinal suture extends from the posterior edge forward to the transverse palatine suture lying within the region of the middle one-third of the horizontal process of the palate bone. The direction of the suture is generally antero-lateral.

TABLE 2

Incidence of lateral longitudinal sutures in the horizontal parts of palate bones in 1548 skulls.

	CASES	RACE				SEX			
		White (675)		Negro (873)		Male (1110)		Female (438)	
		Cases	%	Cases	%	Cases	%	Cases	%
Suture on both sides	2	1	.15	1	.11	2	.18	0	0
Suture on right side only	3	2	.30	1	.11	2	.18	1	.23
Suture on left side only	1	0	0	1	.11	1	.09	0	0

DISCUSSION

Since 4 of the 5 cases of complete medio-palatine bones discussed by Ashley-Montagu ('40) were of Italian origin, he suggests the possibility of the variation being a characteristic of Italians. The case reported by Adachi ('00) but not reviewed by Ashley-Montagu was Japanese. Likewise, the 2 cases presented in this paper do not support the hypothesis of Italian origin since one is an American Negro, and the other is an American White probably of German descent.

The incidences of incomplete lateral longitudinal sutures in the palatine processes of the maxillae as reported by different workers are summarized in table 3. The White groups generally have a higher percentage of this anomaly than either the Mongolians or Negroes with the exception of Adachi's Ancient Egyptian series and Stieda's and Killermann's mixed series which were composed largely of Prussians.

TABLE 3

Incidence of incomplete lateral longitudinal sutures in the palatine processes of maxillae in different series.

SERIES	AUTHOR	TOTAL CASES OBSERVED	CASES WITH THE SUTURES	PER CENT
Mixed (950 Prussians)	Killermann (1894	1520	4	.26
Mixed (953 Prussians)	Stieda (1894)	1382	1	.07
Japanese	Adachi ('00)	328	3	.91
European	Adachi ('00)	408	5	1.23
Ancient Egyptian	Adachi ('00)	135	1	.74
Bohemian	Matiegka ('00)	416	15	3.61
French (Touraine)	Le Double ('06)	512	21	4.10
Alsatian	Frédéric ('09)	99	2	2.02
American White	Woo (present paper)	675	9	1.33
American Negro	Woo (present paper)	873	8	.92

In all cases the medio-palatine bones are limited anteriorly by the incisive sutures and in none do the premaxillae participate in their formation.

The medio-palatine bones are situated in the same plane with the palatine processes of the maxillae and present the

same characteristics with respect to curvature of the vault, degree of roughness and number and size of vascular foramina. Hence they are probably of maxillary origin. Influenced by Killermann's finding of 5 cases in which the base of the vomer was extended between the maxillary palatine plates, Augier ('31) has proposed a vomerine origin for the medio-palatine bones. But Killermann had already mentioned that in these cases there was no hiatus between the interpalatine vomerine elements and the maxillary plates and he considered the medio-palatine bones to be maxillary in origin. Calori (1892) suggested that the outline of the medio-palatine bones may be the result of a series of vascular orifices and Kölliker (1882, cited by Matiegka, '00) and Killermann (1894) proposed that the sutures are due to vascular impressions. In the present series no such characters in any of the anomalous sutures were found. Vram ('03) suggested that the medio-palatine bones may represent cases of incompletely developed torus palatinus. However, as Le Double ('06) pointed out, the torus occurs very frequently whereas the medio-palatine bones are very rare. Ashley-Montagu ('40) as well as Stieda (1894) and Matiegka ('00) believed that the bones probably owe their origin to supernumerary centers of ossification originating in the maxillae. However, Augier ('31) has cleared 180 fetal skulls and found no trace of medio-palatine bones and the present writer has stained and cleared the hard palates of 55 fetuses so far, ranging in age from 6 weeks to full term, and failed to see any trace.

Since in some of the cases of incomplete medio-palatine bones the associated sutures are not continuous but interrupted, the question is raised whether these are remains of sutures which have been partially obliterated or merely suture-like variations in the bone. X-ray films of the hard palates of the 2 skulls presenting complete medio-palatine bones show faint dark outlines of them which the radiologist interprets as suture lines rather than vascular impressions.[2]

[2] Through the courtesy of Dr. Wayne Simril of the Mallinckrodt Institute of Radiology.

If the origin of this anomaly is due to extra centers of ossification, it seems to be reasonable to suppose that the discontinuities are the result of partial obliteration of sutures.

The bones formed by the lateral longitudinal sutures in the horizontal parts of the palate bones are, in fact, medio-palatine in position, though the definition of medio-palatine bones has not been extended to include such cases. It is suggested that they be included in the term, and for the sake of clearness in differentiation it is further suggested that the term "anterior" medio-palatine bones be applied to the bones related to the palatine processes of the maxillae and the term "posterior" medio-palatine bones to the bones formed by the lateral longitudinal sutures in the horizontal parts of the palate bones.

The origin of the "posterior" medio-palatine bones is likewise obscure. Hyrtl (1862) and Augier ('31) attributed it also to supernumerary centers of ossification in the palate bones.

Because of the very limited number of cases of these anomalies, race, sex and age comparisons cannot be made.

SUMMARY

The hard palates of 1548 skulls of American Whites and Negroes were observed. Two cases of the very rare anomalous complete medio-palatine bones were found. One is an old White female probably of German origin and the other is a young Negro male. The bones in the first case extend from the incisive sutures to the transverse palatine sutures and those in the second case are much smaller, situated at the antero-medial part of the palatine processes of the maxillae.

Seventeen cases of incomplete medio-palatine bones, including those limited by almost complete to mere traces of lateral longitudinal palatine sutures in the maxillae, were found in the 1548 skulls. The number of cases presenting the variation was greatest when the extent of the sutures was most reduced.

The lateral longitudinal suture in the horizontal part of the palate bone is even more rare than the suture in the maxillary portion of the palate which forms the lateral

boundary of the medio-palatine bone. Six cases were found in the 1548 skulls: 2 with bilateral sutures and 4 with the suture on one side only. Three of the unilateral sutures are on the right side and the other on the left. The suture generally extends antero-laterally from the posterior edge to the transverse palatine suture within the region of the middle one-third of the horizontal part of the palate bone.

The term "anterior" medio-palatine bones for the bones in the palatine processes of the maxillae and the term "posterior" medio-palatine bones for bones formed by the lateral longitudinal palatine sutures in the horizontal parts of the palate bones are suggested.

The origin of both "anterior" and "posterior" medio-palatine bones may be due to extra centers of ossification.

ACKNOWLEDGMENT

The work was done under the direction of Dr. Mildred Trotter. The writer is indebted to her for constant encouragement and help.

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PLATE 1

EXPLANATION OF FIGURES

Complete anterior medio-palatine bones.

1 and 2 Photograph and drawing of hard palate of White female, age 78, showing complete anterior medio-palatine bones.

3 and 4 Photograph and drawing of hard palate of Negro male, age 13, showing complete anterior medio-palatine bones.

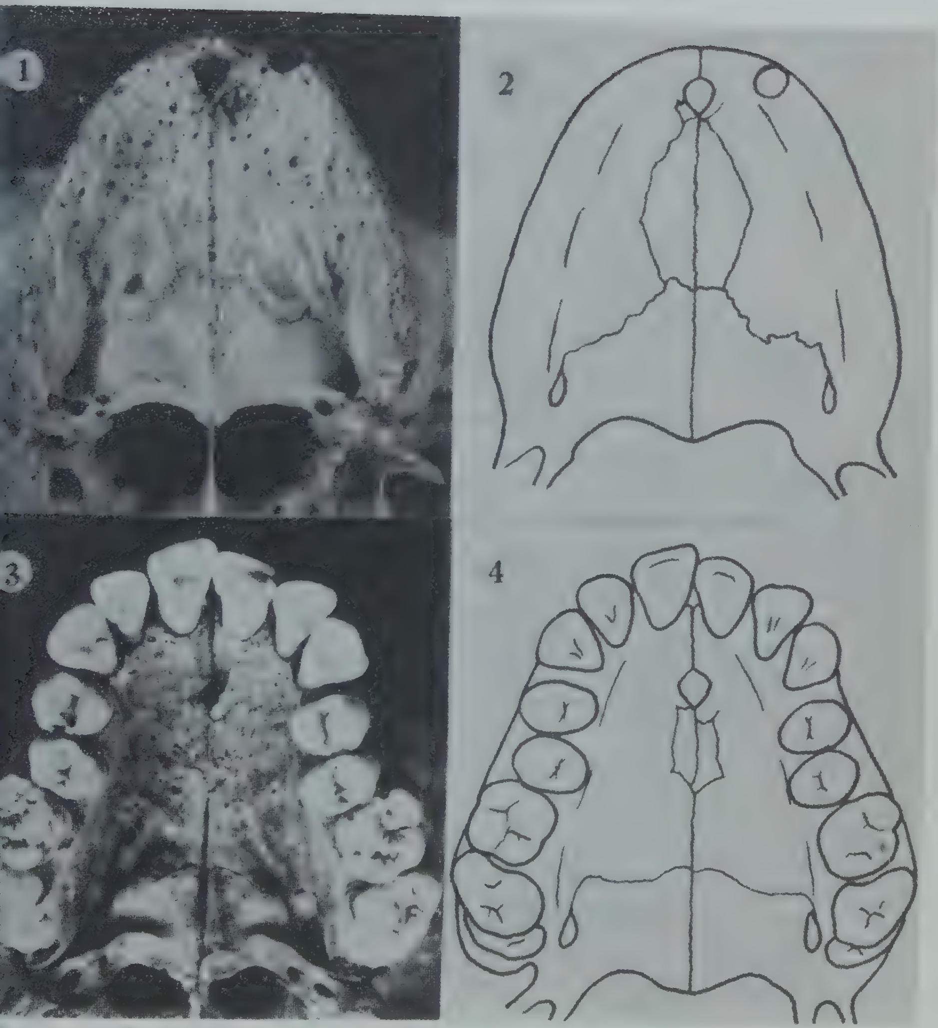
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PLATE 2

EXPLANATION OF FIGURES

Incomplete anterior medio-palatine bones.

5 Hard palate of Negro male, age 58, showing more than three-fourths of the lateral longitudinal palatine sutures present.

6 Hard palate of White male, age 67, showing more than one-half of the sutures present.

7 Hard palate of Negro male, age 30, showing more than one-fourth of the sutures present.

8 Hard palate of White male, age 70, showing traces of the sutures or less than one-fourth of the sutures present.

9 Hard palate of White male, age 78, showing the sutures extending from the posterior one-third of the palatine processes of the maxillae.

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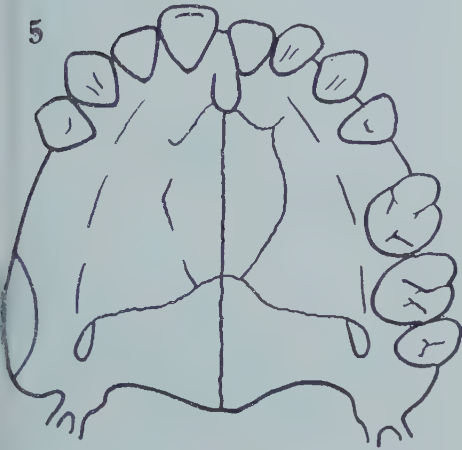

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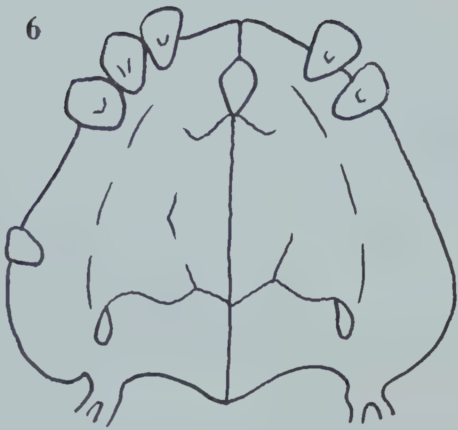

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PLATE 3

EXPLANATION OF FIGURES

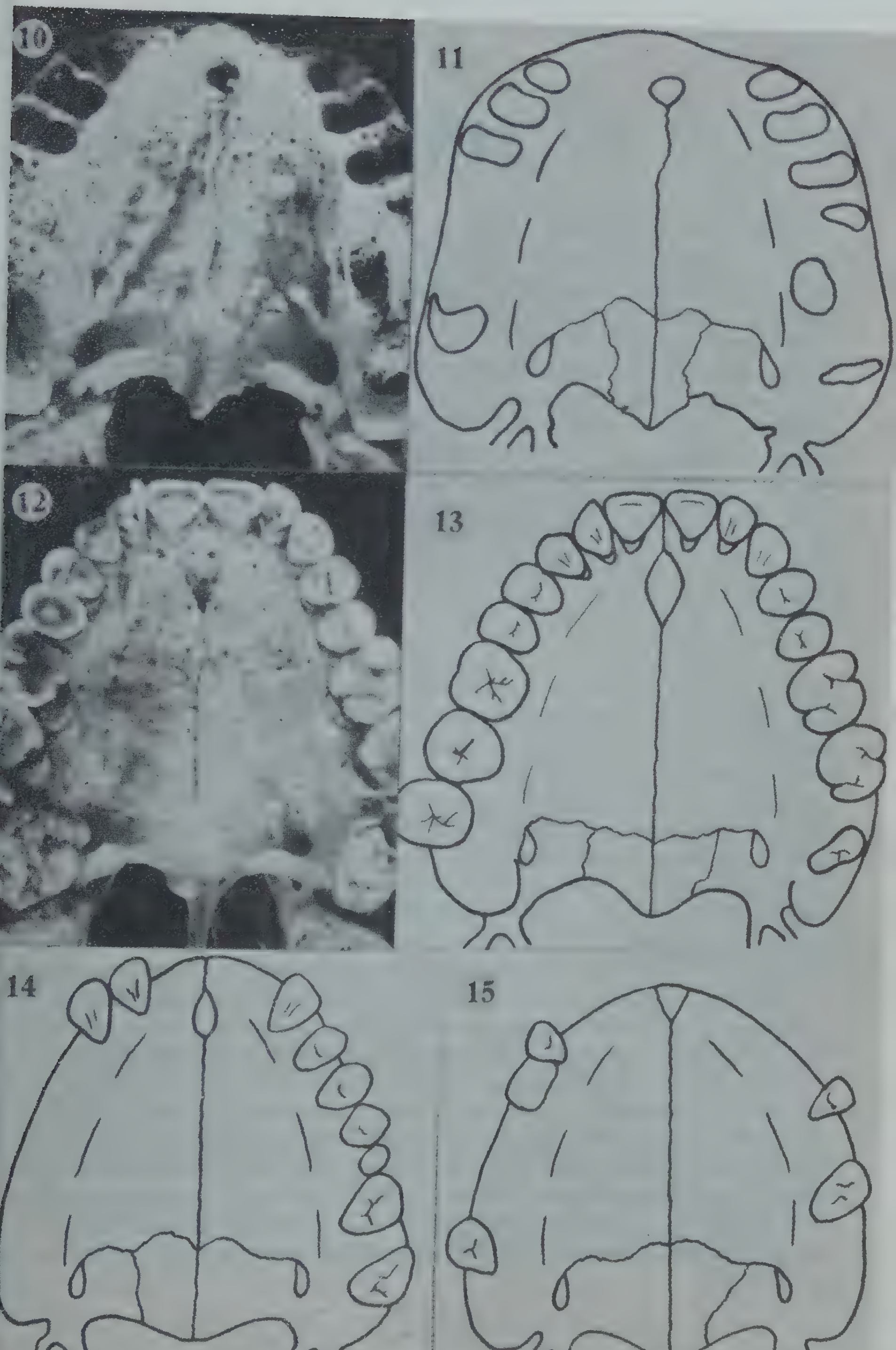
Posterior medio-palatine bones.

10 and 11 Photograph and drawing of hard palate of Negro male, age 51, showing bilateral posterior medio-palatine bones.

12 and 13 Photograph and drawing of hard palate of White male, age 64, showing bilateral posterior medio-palatine bones.

14 Hard palate of White male, age 65, showing unilateral posterior medio-palatine bone on the right.

15 Hard palate of Negro male, age 52, showing unilateral posterior medio-palatine bone on the left.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Etymologic Note.— The habit is unfortunately growing, as scientific progress battens on the decay of the humanities, of coining new technical terms which pay lip-service indeed to the Greek founders of science by drawing upon the lexicon for their elements, but declare their independence by forming them into solecistic combinations. Sir Arthur Keith mildly censures the incorrect form "neoanthropic," and exception may be taken also to "paleoanthropic" for "palaeanthropic," or, in American, "paleanthropic" (one does not say "palaeoontology"); to "archanthropic" for "archaeanthropic" ("arch-" connotes "chief," and not "ancient"); and to *Gigantoanthropus*, for the correct form of which *Pithecanthropus* should have provided a sound precedent.— Editorial note to Arthur Keith's review of *Apes, Giants and Man* by Franz Weidenreich. Man, vol. 47, no. 109, July, 1947, pp. 103–104.

Bibliography of Early Man in America.— This paper, containing notice of the principal investigations of early man in America for the years 1940 to 1945 inclusive, is a continuation of a similar compilation for the years 1839 to 1939, published in 1940 [Bull. Geol. Soc. Am., vol. 51, pp. 373–431]. Special attention is directed to the conditions of occurrence and to the associated fossils. The term early man is used to apply to human materials that, from the stratigraphic conditions, associated fossils and artifacts, or for other reasons, are believed to be of some appreciable antiquity in a geologic sense. Contributions of recent years include a considerable number of papers relating to the time interval between the disappearance or reduction of the great mammalian fauna of the Pleistocene and pottery-bearing horizons. The climatic fluctuations within this time interval have likewise received attention. The stratigraphic units of the early Recent are being differentiated and named and the contained human materials studied. Through the years some progress has been made in determining the implements used by early man in hunting for and processing particular animals; those used in hunting the bison and elephant are among the best known. — E. H. Sellard's abstract of his article entitled. "Early man in America; index to localities and selected bibliography, 1940–1945." Bull. Geol. Soc. Am., vol. 58, 1947, pp. 955–978.

NOTE

EARNEST A. HOOTON
SECOND RECIPIENT OF THE VIKING FUND MEDAL AND PRIZE IN PHYSICAL ANTHROPOLOGY

At the annual dinner of the American Association of Physical Anthropologists at Frazier Hall, Howard University, Washington, D. C., on April 3, 1948, Professor Hooton was awarded the Viking Fund Medal and $1000 Prize in Physical Anthropology. Professor Hooton had been unanimously nominated for this honor by a special committee of 11 members of the Association (Doctors Birdsell, Coon, Dupertuis, Eiseley, Howells, Krogman, Lasker, McCown, Shapiro, Steggerda, Stewart). Acting for Dr. Paul Fejos, Director of the Viking Fund, who was unable to attend the dinner, Prof. Ralph Linton presented the award. He called attention to Professor Hooton's long, fruitful and continuing career in teaching, research and writing in physical anthropology, and pointed out Professor Hooton's proficiency in putting across scientific findings to the public. In responding, Professor Hooton asserted with his characteristic modesty that whereas he did not feel he deserved this signal recognition, he was honored and pleased to receive it. He emphasized that while he is not a "joiner," his participation in the Association's affairs meant a great deal to him, and that he cherished the friendship and stimulation of his colleagues in the Association.

Professor Hooton is the best-known and most influential physical anthropologist in this country. As a teacher, he has trained many of the most active members of this Association. His many published researches have shown breadth, vision, and acumen. His books have been provocatively written, received wide circulation, and, in the case of the "American Criminals," the popular account is backed up by a fully documented tome. The most famous of Professor Hooton's books, however, is "Up from the Ape," which appeared in its second edition in late 1946. Its monumental character has been enhanced by thorough revision and the addition of new sections. The author of the new "Up from the Ape" richly merits the second Viking Fund award in physical anthropology. His colleagues are happy to see him thus honored.

(Photo by Scurlock, Washington)

Professor Hooton (right) and President Krogman admiring the Viking Medal held by Professor Linton.

PROCEEDINGS

OF THE SEVENTEENTH ANNUAL MEETING

OF

THE AMERICAN ASSOCIATION OF PHYSICAL ANTHROPOLOGISTS

The seventeenth annual meeting of the American Association of Physical Anthropologists was held on April 2, 3, and 4, 1948, at the United States National Museum, Washington, D. C.

PROGRAM

April 2	9:00 A.M.	Registration
	9:45 A.M.	Scientific papers 1–7
	2:15 P.M.	Scientific papers 8–16
	8:00 P.M.	Smoker at Raleigh Hotel
April 3	9:00 A.M.	Scientific papers 17–20
	10:30 A.M.	Tour of Federal Bureau of Investigation laboratories
	1:30 P.M.	Business meeting
	2:30 P.M.	Symposium in applied physical anthropology: Papers 21–29
	7:00 P.M.	Annual dinner at Howard University. Presentation of Viking Fund Medal and Prize in Physical Anthropology
April 4	10:00 A.M.	Scientific papers 30–37

BUSINESS MEETING

The minutes of the last meeting were accepted.

Dr. Stewart mentioned the possibility of having anthropometric instruments made at approximately $150 per set. President Krogman, Dr. Shapiro, Dr. Steggerda and Dr. Stewart were constituted as a committee to continue working on the problem of tools.

The nominating committee offered the following nominations:

For Vice-President	Montague Cobb
For Executive Committee	Sherwood L. Washburn

Both were unanimously elected.

The following were elected to membership in the Association:

A. W. Angulo
Ernst Büchi
Edward C. Colin
Frank C. Cross
Eusebio Dávalos Hurtado
Donald Duncan
Nancy Durant
Joan Finkle
Jacob Gouber
Şevket Aziz Kansu
Bernice Kaplan
Henry Klein
Bertram S. Kraus
Benjamin N. Kropp
Paul W. Lapidus
Victor E. Levine
Pauline B. Mack
Ruth Ann Marzano
G. Albin Matson
Dolores Nourse
Paul Reiter
Gordon H. Scott
James N. Spuhler
Frederick L. Stagg
Walter E. Sullivan

The Treasurer's report, as follows, was accepted.

TREASURER'S REPORT

Endowment Fund

Prudence Bond		$ 100.00
U. S. Savings Bonds, maturity value		3,000.00
		3,100.00
Bank balance December 18, 1946		$1,076.29
Receipts		
By S. L. Washburn (Dec. 18, 1946 to Jan. 1, 1947)	$ 212.00	
Dues subsequent to January 1, 1947	1,302.52	
Subscriptions to Am. J. Phys. Anthrop.	12.00	
Disbursement, Prudence Bond	50.00	
Viking Fund, grants in aid to publication	900.00	
Viking Fund, grant to representative to International Congress	500.00	
Interest, savings account	3.79	
		$2,980.31
		$4,056.60

Expenditures

To Wistar Institute for subscriptions to Am. J. Phys. Anthrop.	$1,021.00	
Secretarial expenses	83.81	
To S. L. Washburn for meeting room at Chicago meeting	7.50	
To Am. Anthrop. Assn. for Chicago meeting programs	10.46	
Dues to Inter-American Soc. of Anthropology and Geography	3.00	
Contribution to Union of American Biological Societies	15.00	
To T. D. Stewart. Grants in aid to publication	900.00	
To Viking Fund. Unspent grant for representative to Internat. Congr.	500.00	
To Wistar Institute for reprints of proceedings	38.83	
To J. B. Birdsell to represent the Association at Am. Anthrop. Assn.	50.00	
Bank charges, checking account	6.13	
		$2,635.73
Bank balances, March 15, 1948:		
Checking account	267.08	
Savings account	1,153.79	
		$1,420.87
		$4,056.60

March 16, 1948
Respectfully submitted,
GABRIEL LASKER,
Treasurer

Certified to be as stated above:
April 2, 1948
STANLEY MARION GARN
EARL W. COUNT

The Association appropriated $150 to cover secretarial expenses in 1948. The Secretary was empowered to spend not over $50 of this amount to cover his travelling expenses to the annual meeting of the Association.

The Editor submitted a report on the Journal in which he pointed out that his backlog of manuscripts had dwindled away. In this connection he called attention to the large proportion of recent manuscripts that have come from individuals

who are not members of the Association. He reported also that aid was extended to authors to defray the cost of extra illustrations, as follows:

Balance reported last year			$174.92
Grant from the Viking Fund, May, 1947			400.00
Total			$574.92
Paid to Wistar Institute for Mss. of			
Jones, Harold E.	vol. 5, no. 1	(p. 29– 39)	$10.00
Jones, Hector G.	vol. 5, no. 3	(p. 251–281)	50.00
Lipschutz, A. et al.	vol. 5, no. 3	(p. 295–321)	67.00
Lasker, Gabriel W.	vol. 5, no. 3	(p. 323–341)	33.00
Weidenreich, Franz	vol. 5, no. 4	(p. 387–427)	70.00
Dankmeijer, J.	vol. 5, no. 4	(p. 453–484)	121.68
Chase, R. and C. R. DeGaris	vol. 6, no. 1	(p. 85–109)	22.00
		Total	$373.68
		Balance	$201.24

The Editor's report was accepted with the thanks of the Association to Dr. Stewart for his successful conduct of the post during the difficult years of his term in office. The Association accepted the recommendation of the Executive Committee that Dr. Howells be elected to the editorship for the next 6-year term. It also accepted the suggestion of the present editor that Dr. Howells be permitted to name Associate Editors to fill the vacancies. The new editor has submitted the names of Dr. Boyd and Dr. Stewart, the latter to fill out Dr. Howell's own unexpired term as Associate Editor.

The editor of the Newsletter, President Krogman, reported that the amount of work now involved can be accomplished within the budget of $50 only if there is more help with the mimeographing by other members. On his recommendation the Association voted $50 for continuance of the Newsletter.

The representative to the Executive Board of the American Anthropological Association, Dr. Birdsell, submitted a report. The Association was invited to join in measures for the relief of needy anthropologists in Europe. The report of Dr. Bowles, the representative on the Committee on International Cooperation in Anthropology, raised the same question. As it

was stated by Dr. Shapiro and others that the Viking Fund has made a grant for C.A.R.E. packages for European anthropologists, and that all names so far submitted by Dr. Collins have received aid, the Association took no further action at this time. However, the need for books and journals was stressed, and members were invited to help in this way and through submitting additional names of needy anthropologists abroad to Dr. Collins.

Dr. Lasker reported that the Viking Fund Physical Anthropology Seminar will again be held at the Viking Fund in New York from June 22nd to July 1st inclusive. The first week will be devoted to a consideration of human growth, the second week to human evolution. Professor W. E. Le Gros Clark, chairman of the Department of Human Anatomy at Oxford University, will be present and will speak at the Hunter College Playhouse at 8:00 P.M. on July 1st. Members of the Association were invited to attend.

Dr. Newman reported on the drive for new subscriptions for the Journal. Because of the generosity of The Wistar Institute in preparing and sending out brochures, the $100 budgeted by the Association for this purpose was returned to the treasury. Among the 263 museums and libraries circularized, 30 have now subscribed to the Journal. It is planned to continue the drive with the cooperation of the members. Dr. Newman's report was accepted with warm thanks.

In recognition of outstanding service to the Association and to physical anthropology President Krogman presented the following resolution on behalf of the Executive Committee:

Be it resolved that the officers be authorized to include the following words in the official description of the Association:

"*Benefactors*

The Viking Fund, Inc. The Wistar Institute of Anatomy and Biology"

The resolution was unanimously passed. The names of the benefactors will be listed with the names of the officers and members in the proceedings as a token of the Association's appreciation for the help these institutions have rendered.

The attention of the Association was called to the fact that not a single application for the National Research Council Fellowship in the division of psychology and anthropology was received this year. Applications are due by November 1st.

In view of the fact that the Viking Fund has generously given the Association a very free hand in making nominations for the Viking Fund Medal and Prize in Physical Anthropology, the following recommendations of past nominating committees were presented by President Krogman and accepted by the Association: that the nominating committee shall consist of the officers of the Association plus 5 other members so that all branches of physical anthropology will be represented; that nominees may be international; that ballots be accompanied by a written statement supporting the choices; that research reported in the given year be given prior eligibility over previous work; and that if no new work be worthy, the award be vacated for the given year.

Dr. Bowles' report noted the paucity of representation from the United States at recent international congresses. In view of a letter from Dr. Cummins stating his desire to attend the forthcoming Third International Congress of Anthropological and Ethnological Sciences in Belgium, and the disappointment over the cancellation of last year's plan for a meeting at Prague, the Association thanked the Viking Fund for their effort to help last year and authorized the secretary to enquire whether they now might make a grant to enable the Association to send Dr. Cummins as an official representative to the congress.

Dr. Shapiro informed the Association that through the generosity of the Viking Fund the American Anthropological Association has been enabled to extend an invitation to the International Congress of Americanists to meet in New York during the summer of 1949. The Association approved plans to join in this invitation.

Members of the Association received a cordial invitation to attend and participate in the 7th Pacific Science Congress to be held in New Zealand in February 1949.

Dr. Montagu proposed that the Association institute a Founder's Lecture in honor of Dr. Aleš Hrdlička to whom we owe the establishment of the Association and of the American Journal of Physical Anthropology. The matter was referred to the Executive Committee for consideration.

Dr. Ehrich reported for the Resolutions Committee. They introduced the following resolutions:

Be it resolved that the Association hereby express its deep appreciation to its Washington hosts, the United States National Museum and the Anthropological Society of Washington; and to their representatives, Dr. T. D. Stewart, Dr. M. T. Newman and the local committee for the facilities accorded the Association and for the numerous arrangements which they made on its behalf.

Be it also resolved that a vote of thanks to Howard University be recorded in recognition and appreciation of the hospitality extended by the University to the Association.

Be it also resolved that a vote of thanks to Mr. J. Edgar Hoover and the Federal Bureau of Investigation be recorded, as a mark of indebtedness for an extremely interesting visit to the F.B.I. laboratories by members of the Association.

And be it further resolved that a copy of this resolution be printed in the Proceedings of this association, and that copies be sent to the persons and institutions mentioned.

These resolutions were unanimously adopted and the meeting adjourned.

ANNUAL DINNER

Approximately 65 persons attended the annual dinner. When they were seated Prof. Cobb voiced a welcome from Howard University, concluding his remarks with a statement to the effect that it was nice to have them as guests even though they were having to pay for their dinners. After the delicious meal had been served President Krogman called on Prof. Cobb to introduce Dr. Mordecai Johnson, president of the University. Dr. Johnson corrected Prof. Cobb's earlier statement by saying that those present were dinner guests of the University. This generous gesture was heartily applauded. He then went on to give a sketch of the history of Howard

University from its founding to the present, stressing interracial composition of trustees, faculty and students, and the excellent relations that had always prevailed. At the close of his talk the audience arose applauding.

President Krogman thanked Dr. Johnson on behalf of the Association for the hospitality extended by Howard University, and announced that by unanimous consent of the Executive Committee, which he had hastily polled, the money received from the sale of tickets to the dinner, \$234.35,[1] would be turned over to the University for use in physical anthropology.

President Krogman then introduced Prof. Linton, who, as representative of the Viking Fund in the absence of Dr. Fejos, made the award of the Viking Fund Medal and Prize in Physical Anthropology for 1947 to Prof. E. A. Hooton (for a further account of this award see p. 225).

SCIENTIFIC PAPERS

The titles and abstracts of papers read at the scientific sessions follow:

1. *Precision in anthropometric techniques. I. The measurement of stature.* W. Montague Cobb, Department of Anatomy, Howard University.

The accuracy of the measurement of stature as represented by the distribution of 150 determinations of the stature of each of 4 men is shown. On 5 consecutive Saturdays, at about the same time of day, and in the same place, each man made 10 successive measurements of the other 3 with a Martin anthropometer. Each week attempt was made to profit from previous experience in the reduction of error. The anthropometer readings were made by an independent recorder without communication with the measurer. The individuals varied greatly in constancy of the stature dimension, both on the same day and on different days, and when measured by the same observer and by different observers. Allowances for error in measurement of stature which do not take into account variation in the subject are unsound. Presumption that differences in measurements by 2 observers should not exceed 5 mm is unjustifiable.

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[1] This includes the unexpended portion of a generous donation from the Anthropological Society of Washington for entertainment.

2. The role of certain endocrine organs in the growth and development of the hair. Stanley Marion Garn, Harvard University, Forsyth Dental Infirmary, and the Massachusetts General Hospital.

The growth of hair upon any part of the body depends upon 2 factors — the presence of the necessary trophic hormone, and the genetically determined responsiveness of the follicles. The majority of the endocrine secretions affect the hair not directly, but through their general effect on the organism. Hence in insufficiency of thyroxin, parathyroid hormone or cortical hormones hair loss follows the appearance of general debility. Myxedema, hypoparathyroidism, hyperparathyroidism, and Addison's disease are all capable of initiating partial or total alopecia.

The growth hormone of the anterior pituitary, and the androgenic hormones of testicular and adrenal origin affect the follicles more directly. In man, even more than in the anthropoids, there is a division between those follicles that normally respond to growth hormone and those that respond to the "triggering" influence of the androgens. Head, eyebrow, eyelash, and lower extremity hair are responsive, both in growth rate and coarseness, to growth hormone. In conditions characterized by excessive growth hormone the hair coarsens rapidly — as in acromegaly. But in the absence of normal growth hormone, as in panhypopituitarism, the normal coarsening of age may be absent.

The axillary and pubic hair, and to a lesser extent the beard hair, respond directly to androgenic hormones. The body hair, with the exception of certain minor areas, is also "triggered" by androgens. Sex differences in genetically similar individuals are largely due to quantitative differences in androgen production. Differences in the amount of body hair in individuals of the same sex are normally genetic, rather than endocrine in origin. In normal individuals the amount of body hair is a function neither of "masculinity" nor of "femininity."

3. Age changes in index and size of hair in children. Mildred Trotter and Oliver H. Duggins, Department of Anatomy, Washington University, St. Louis.

Sixteen white children of American parentage have provided samples of crown hair monthly since birth (the oldest is now 17 and the youngest 5). Fifty hairs from the first month's sample and from each 6 months' sample thereafter have been measured for the greatest and least diameters. From these diameters the index and cross-sectional area have been determined.

The index drops sharply during the first 2 years of life. However, following the second year it is irregular with no uniformity in trend. The cross-sectional area increases at a rapid and uniform rate during the first 3 years of life, and somewhat less rapidly and less uniformly thereafter. Among the subjects are 5 pairs of siblings: each pair shows similar trends in index and size with the most similarity between the identical twins.

This study was aided by grants from the Viking Fund and the U. S. Public Health Service.

4. *The blood groups of Alaskan Eskimos.* Victor E. Levine, Department of Biological Chemistry and Nutrition, Creighton University School of Medicine, Omaha, Nebraska. (Introduced by S. L. Washburn.)

The bloods of 322 Eskimos in Arctic Alaska were tested. With one exception (subgroup A_1A_2), all bloods in groups A and AB fell into subgroups A_1 and A_1B. Type N for reputedly pure Eskimos was 4.72% and for natives of mixed ancestry, 5.88%. Admixture increased type N and decreased the ratio of $\sqrt{M} : \sqrt{N}$. This relationship holds true also for American Indians. The Rh factor of 120 Eskimos of putative purity proved 97.5% positive. Eskimos resemble Mongoloids in the incidence of subgroup A_1 and of the Rh factor, but differ from them with respect to group B and type N.

Eskimos resemble American Indians in the frequency of the Rh factor, in the incidence of group B and of subgroup A_1 to the exclusion of subgroup A_2, and in the incidence of type N. Eskimos and Indians possess the lowest, while Australian aborigines possess the highest incidence of type N.

Our serological findings support those of cultural anthropologists, archaeologists and physical anthropologists with reference to the cultural and anthropometric similarities between Eskimos and Indians of North America, and strengthen their contention that the Eskimos were originally of Indian stock living inland in North America, who finally spread northward, eastward and westward, adapting themselves to a life compatible with Arctic conditions and developing the Eskimo culture as we knew it in historic times. The Eskimo culture originated in North America and was not transplanted from Asia by way of Bering Strait.

5. *Blood grouping tests in anthropology.* A. S. Wiener, Brooklyn, N.Y. (Read by title.)

The discovery of numerous new individual differences in human blood has established for blood grouping an important place in anthropology. Subdivisions of mankind based on blood group differences correspond well with those based on physical and geographical considerations as shown by the following:

CAUCASOID GROUP: Highest frequency of gene *r* (Rh negative); about ¼ to ⅕ of group A individuals in subgroup A_2; M slightly in excess of N.

NEGROID GROUP: Very high frequency of gene R°; many A_2 individuals and individuals with so-called intermediate A; M slightly in excess of N.

MONGOLOID GROUP: Gene *r* relatively rare; A_2 also virtually absent.

Asiatic subgroup — M slightly in excess of N as in Caucasoids and Negroids.

Pacific Island and Australia — N much more frequent than M.

Amerindians and Eskimos — M much more frequent than N.

The study of the blood groups and Rh-Hr types has also solved some problems of historical interest. E.g., as shown by Candela the decreasing incidence of gene *B* proceeding from East to West in Eurasia reflects the effects of the Mongolian invasions. Moreover, as shown by Wiener and Haldane, the present distribution of the Rh types among Caucasoids indicates that this group arose by crossing between two or more primitive stocks, some with high others with low frequency of gene *Rh*; otherwise, either the Rh-positive or the Rh-negative gene should have been virtually eliminated by now as a result of isoimmunization in pregnancy.

The unique blood grouping pattern of Basques, with high gene r and low gene B, corresponds with their isolated geographical position and freedom from mixture with Mongoloid and other peoples, as shown also by their unique language and customs.

6. *Preliminary tests for presence of blood group substance in Tepexpan man.* William S. Laughlin, Peabody Museum, Harvard University.

At the suggestion of Sr. Javier Romero preliminary examinations for the presence of blood group substances in the skeleton of Tepexpan man were performed. Dr. William C. Boyd provided the sera, the facilities of his laboratory at Boston University School of Medicine, and supervision of the experiments.

The method employed was that of the absorption technique similar to the method used by earlier workers for determination of blood stains on cloth. This method was employed with excellent results by Dr. P. B. Candela in testing the skeletons of Aleut mummies. These tests involve the application of serum of known strength to a specimen of pulverized bone. If the group substance which determines the blood type is present in the specimen of bone, the antibodies of the serum are wholly or partially absorbed and the strength of the serum is thereby reduced. After a suitable period of incubation the supernatant serum is drawn off the specimen and tested against red cells of the appropriate group. Failure to agglutinate these cells is presumptive evidence that agglutinins were removed from the serum and therefore that the group substance was present in the skeletons tested.

In a series of tests using 2 Khustenete Indian skeletons as controls, specimens of bone from Tepexpan man reduced the strength of the anti-A serum applied to it. Tentative evidence therefore exists for the presence of group substance A in Tepexpan man. Possibility of non-specific absorption will be thoroughly investigated in future tests. Tests will also be made with the electron microscope and with the infra red spectrophotometer in a further attempt to demonstrate the presence of organic substance.

7. *The limb bones of Australopithecines.* William L. Straus, Jr., Department of Anatomy, The Johns Hopkins University.

The limb bones ascribed to Australopithecines include the lower end of a humerus, a proximal ulnar fragment, a capitate, a metacarpal, an innominate, the distal end of a femur, and a talus.

Detailed comparison of a cast of the Australopithecine humerus with those of other primates reveals that this fragment falls within the ranges of variation of *both* man and anthropoids, notably chimpanzee. This region is essentially so similar in man and anthropoids that it has limited value for phylogenetic deductions and gives no clue to general forelimb structure. It does not warrant the conclusion that the Australopithecine forelimb was not used in locomotion.

The writer has been unable to study casts of the other limb bones. Judging from the published accounts and drawings of Broom and LeGros Clark, however, it is not justifiable to conclude that the Australopithecines were "evidently capable of standing and walking with an almost erect posture." The non-anthropoid char-

acters of the femoral fragment are common to *both* man and catarrhine monkeys and are not necessarily associated with erectness. The innominate appears so similar to that of Bushmen that its Australopithecine nature may be questioned. Both capitate and talus apparently present a mixture of human and simian characters, but more detailed comparisons with other primates are in order before final decisions can be attained.

Finally, it remains to be proven that these bones are not of diverse origins — human, simian, and Australopithecine. Until that is reasonably settled, and the bones themselves are properly studied, all conclusions are premature.

8. The most characteristic morphological difference between early hominids and modern man. Franz Weidenreich, American Museum of Natural History.

The most characteristic feature in which the skull of modern man differs from that of earlier human forms, including the Neanderthalians, is the greater height of his braincase. This is not due to a greater expansion of the braincase and brain, but to the deflection of the base which turns the whole rear part of the braincase behind the vertex downward and forward, brings the nasion and basion closer together, and lifts the vertex to a higher level. The 2 Solo skulls, VI and XI, in which the critical parts of the base are preserved, made possible the study of this transformation for the first time. Neither skull shows any sign of deflection, and the topographical arrangement of the fossae cerebri reflects this primitive condition. Photographs of negatives taken from the interior of the skulls, exposed in midsagittal sections, reverse the usual picture so that the cavity appears like the convex of an endocast. By this procedure structures which never before attracted attention become clearly recognizable. They show that the pons and medullar portion of the brain stem reach much higher in modern man than in Solo man or any anthropoid, and that the cerebellum occupies a vertical position like the medulla and not a more horizontal one as in Solo man and anthropoids. All this results from the deflection of the base and, therefore, in a more complete adjustment to the perfectly erect posture.

9. The Sylvian depressions on the endocranial casts of anthropoids and man, and their interpretation. C. J. Connolly, Catholic University.

The depressions in the Sylvian area of endocranial casts of fossil anthropoids and prehistoric man have received various interpretations with respect to the probable development, or lack of it, in the corresponding part of the brain. In order to test the degree in which the endocast reflects this area of the brain as well as the fissuration in general, endocasts of anthropoid and human skulls were made and compared with the corresponding brains.

Examination revealed that young and very old specimens of anthropoids generally show no Syvian notch or Sylvian depression, while young adults may reproduce a definite Sylvian notch and Sylvian depression on the cast. The anterior part of the depression is formed by an expansion leading from the lesser wing of the sphenoid and generally includes the position of the superior temporal sulcus. The middle and caudal part of the Sylvian may be represented as a result of an expansion or formation of a *jugum cerebrale.*

Comparison of a human endocast with the corresponding brain showed that, while a deep Sylvian notch and extensive Sylvian depression is present on the cast, the insula of the brain is not exposed more than in the average brain. The cortex of this brain is depressed along the course of the Sylvian fissure as a result of the development of a *crista Sylvii* in a skull of more than average thickness.

This study on endocranial casts of anthropoids and man, forms part of a book on the external morphology of the primate brain now in press.

10. A hybrid gibbon with some remarks on the problem of species. M. F. Ashley Montagu, Department of Anatomy, Hahnemann Medical College and Hospital, Philadelphia, Penna.

A cross is described between a female *Hylobates agilis* from Sumatra, and a male described as *Hylobates lar pileatus* but which is probably *Hylobates hoolock*. The latter animal was purchased from a dealer and is presumed to have come from Siam. Both animals were received at the United States National Zoological Park, Washington, D. C., in May 1938. On 20th October 1944 the female gave birth to a daughter, who was named ''Barbara.'' All 3 animals are today in excellent condition.

The pelage of the mother is a rich dark calf brown with a plum or maroon tinge. The exposed skin is everywhere dark brown in color. The pelage of the male is totally black except for the usual distribution of white hairs in *Hylobates hoolock*. The skin color on all visible surfaces is black.

Bearing in mind age changes and color phases in the gibbon, Barbara's pelage is very different from that of her parents, her hair color being dominantly gray without a single hair having the color of her mother's pelage. Her skin color is black.

The number of species now recognized among the Hylobatidae is questioned. It seems clear that *agilis* and *hoolock* are geographic races of a single polytypic species.

11. The milk and permanent dentitions of the Tarsius philipensis. Albert A. Dahlberg, Chicago, Ill.

The dentition of Tarsius philipensis is relatively primitive in some characters and highly specialized in others. Study of the tarsiers in the collection of the Chicago Natural History Museum revealed that only 3 of the adult functional teeth are preceded by deciduous teeth. These are the canines and the posterior 2 premolars (Pm 3 and Pm 4). The other constituents of the functioning milk dentition are the tips of the permanent teeth. The most anterior premolar (Pm 2) was found to be 1 of the first 3 teeth erupted, the other 2 (dM 3 and dM 4) being the predecessors of the last 2 premolars (Pm 3 and Pm 4). The tips of I 1 (upper and lower) and I 2 (upper only) erupt soon thereafter. The deciduous canines and the permanent first molars are next. The second permanent molars follow. Contrary to expectations Pm 4 (the third tooth in the pre-molar series) develops and erupts ahead of Pm 3. The permanent canines erupt after Pm 4 but before Pm 3. M3 is the last to appear in the dentition. To summarize, the eruption sequence is (Pm 2, dM 3, dM 4), I 1 (I 2, dC 1, M 1), M 2, Pm 4, Pm 3, M 3. This

is based on x-ray and oral examination of the 1 foetus and 4 infant tarsiers of differing ages from the collection.

12. *The palatine ridges of primates.* Adolph H. Schultz, Department of Anatomy, The Johns Hopkins Medical School.

The transverse palatine ridges, or rugae, present in nearly all mammals, are found in a primitive, undifferentiated condition in the Lemuroidea in which they are regular, symmetrical, large, covering the entire hard palate, and numbering about 7 on each side. Tarsiers, howler monkeys and chimpanzees show the most pronounced trend to increase the number of ridges, whereas Hapalidae, gorilla and man possess reduced numbers of rugae. A phylogenetic change to complicated, irregular ridge patterns has occurred repeatedly among simian primates, especially in several platyrrhines, in the great apes and in man. These ridges tend to disappear from the aboral part of the hard palate in various monkeys of the Old and the New World and, particularly, in great apes and man. Of all primates man possesses the smallest average number of ridges (4 on each side) and the proportionately largest aboral palatine area, free of rugae. Individually, however, these conditions overlap extensively in man and great apes.

The number, arrangement and relative size of these ridges, which appear very early in prenatal life, remain unchanged throughout growth in man and other primates.

From a study of single-ovum twins it appears that there is a genetic basis for the degree of irregularity and the prevalence of ramifications and discontinuities of the ridges, but not for the details of individual ridge patterns.

13. *''Anterior'' and ''posterior'' medio-palatine bones.* Ju-Kang Woo, Department of Anatomy, Washington University, St. Louis.

The hard palates of 1548 skulls of American Whites and Negroes were observed. Two cases of the very rare anomalous complete medio-palatine bones were found: one in an old White female probably of German origin and the other in a young Negro male. In addition, there were 17 cases of incomplete medio-palatine bones, in which the associated lateral longitudinal palatine sutures were of reduced extent.

The lateral longitudinal suture in the horizontal part of the palate bone is also very rare. When present it forms a boundary of another anomalous palatal bone related to the horizontal process of the palate bone. Six cases were found of which 2 presented the bones bilaterally and 4 unilaterally.

Since the incidence of these anomalous bones is so small, race, sex and age comparisons cannot be drawn.

The term ''anterior'' medio-palatine bones for those related to the maxillary portion of the hard palate and the term ''posterior'' medio-palatine bones for those related to the palatine portion of the palate bones are suggested.

14. *Femoral deformation studies.* F. Gaynor Evans, H. R. Lissner and Herbert E. Pedersen, Departments of Anatomy and Engineering Mechanics, Wayne University.

Static and dynamic loading studies of adult human femora revealed the following: with vertical loading the superior and the anterolateral (convex) aspect of

the neck and shaft, respectively, are under *tension* stress while the opposite aspects of the bone are under increased compression. The femur behaves as an elastic body. The lateral condyle is the greater weight-bearing condyle when the bone is vertically oriented and loaded. The static load was 400–1280 pounds, the dynamic load 15.8 inch pounds. No deformation pattern occurred with the latter amount of energy when the infracondylar plane made a 3 degree angle with the horizontal plane. With this orientation 23.7 and 31.6 inch pounds of energy were used. The resulting pattern on the neck was similar to those obtained previously, but the shaft pattern was more extensive. With the medial condyle on a concrete floor and the head on a steel block 13 mm thick, 31.6 inch pounds dynamically applied to the greater trochanter produced a pattern on the inferior and the medial aspect of the neck and shaft, respectively. A statically applied force of 149.4–498.0 inch pounds of torque produced a pattern tending to spiral around the shaft. The cracks are at a 45 degree angle to the long axis of the shaft. Some spiral fractures of the shaft were also produced. The cracks in the ''stresscoat'' lacquer arise from *tensile* deformation in the underlying bone. The cracks are transverse to the direction of *tensile* stress within the bone.

15. The so-called longitudinal arch — some new thoughts. Paul W. Lapidus, New York City. (Introduced by W. M. Krogman.)

The longitudinal arch of the human foot is not analogous to a masonry arch. Man is the only primate who has fully adopted the upright plantigrade stride, and only man has a longitudinal arch. Even in man, longitudinal arching does not develop before the third or fourth month of intra-uterine life, and from then on to adulthood the arch gradually grows higher. The shock-absorbing functions of the longitudinal arch have been accepted unquestioningly by many generations of anatomists, who compared the arch to the semi-elliptical spring of a carriage. This conception appears to be unacceptable since the arch could have springiness only if the plantar fascia and ligaments were elastic, which they are not.

According to the author, the foot is a rigid frame built on the principle of a truss, with foot bones bearing compression stress, plantar fascia and ligaments taking up the tensile stress, while bending stress is being eliminated. Thus, the arch is really a rigid truss created to provide strength, in response to the new functional requirements of the upright plantigrade stride.

The author believes that the integrity of the arch or foot truss in standing, is maintained mainly by passive support of the ligaments, the muscles playing a secondary part.

16. Visible evidence of humeral torsion: the bicipital groove. Vernon E. Krahl, Department of Gross Anatomy, Unviersity of Maryland School of Medicine.

All agree that the humerus is a twisted bone, but many have mistakenly assumed that the torsion occurs in the diaphysis because of the illusion of twisting created by the spiral or radial groove. If torsion has left its mark anywhere upon the humerus, it should be evidenced at the proximal end of the bone, for it has been shown that the site of humeral torsion is at the proximal diaphyseo-epiphyseal joint. The bicipital groove, which crosses the proximal epiphyseal line,

appears to have been implicated in the process of torsion. In the adult humerus the bicipital groove describes a gentle spiral from lateral to medial as it descends, being more marked in some bones than in others. The angle through which the groove turns in its descent (the spiral angle) bears a constant relationship to the torsion angle. Moreover, the spiral angle, like the torsion angle, shows a gradual increase with age until about the twentieth year. The increase in the angles and the maximum which they attain are directly related to the forces of the muscles which rotate the humerus. The spiral course of the bicipital groove is clearly visible evidence that the humerus has undergone a torsion, and supports the views that the twist is a medial one and that it is localized at the proximal diaphyseo-epiphyseal joint.

17. *A Macedonian refuge area and stability of type.* J. L. Angel, Daniel Baugh Institute of Anatomy of the Jefferson Medical College.

A sample of 24 farmers from the sparsely populated small southern plain of the Chalcidice differ from the stocky, brachycephalic, broad-jawed, and brunet average Greek (e.g. in West Macedonia or Central Greece) in being taller, longer-legged and more linear, with much narrower, lower, longer head, stronger cheekbones, more concave nose, and less brunet coloring. They resemble Neolithic and pre-Greek populations more than typical modern or even Classical Greeks. Similar linear variants are tentatively identifiable along the margins of those fertile gulf plains and seaport areas facing S.E. where the descendants of the pre-Greek first settlers for over 5,000 years have been gradually changed by Alpine-Dinaric infiltration from the northwest mountain refuge areas. But apparently these pre-Greek survivals in refuge areas bordering the plains have not escaped change entirely. Chalcidicans differ from pre-Greeks in lower head and broader jaws (Mycenaean and Classical Greek traits), long upper face and nose compared to mouth region (modern trait), prominent malars (''Ladogan'' or even Mongoloid trait), and probably also tall stature (''Serbian'' trait). Thus the Chalcidic low variability (Sigma Ratio less than 90%) and persistence of rugged and gracile Mediterranean blend seems a function of Medieval selection (by malaria, substandard diet, and emigration) rather than isolation alone. Stability is not genetic stagnation. And this past stability has interest for future developments resulting from refugee immigration from Anatolia and Thrace reaching 27% of the Chalcidic population, as well as from improved health conditions and high birthrate. Some prediction of this future blending can be reached from the anthropology of Anatolian and Thracian Greeks.

18. *Somatotypes and blood volume.* C. W. Dupertuis, Presbyterian Hospital, New York City.

In order to investigate the relationship between somatotypes and blood volume the Constitution Research Laboratory and Drs. Gregerson and Nickerson of the Physiology Department of the Columbia Medical School conducted some joint studies on a series of 53 medical school students. Somatotype photographs were taken by Drs. Dupertuis and Sheldon and the somatotypes were correlated with

the blood volume determinations made by the physiologists. Blood volume was determined by the dye method described by Gregerson.

The results showed a negative correlation ($r = -.65$) between blood volume (cm^3/kg) and endomorphy and a positive correlation ($r = +.54$) between blood volume (cm^3/kg) and ectomorphy. Similar correlations were found between serum volume (cm^3/kg) and endomorphy and ectomorphy again between cell volume (cm^3/kg) and the same two components.

When blood volume was calculated in cm^3/cm of stature there appeared a positive correlation ($r = +.45$) between this determination and mesomorphy. The correlations with endomorphy and ectomorphy were not significant. The same results were obtained in the serum volume (cm^3/cm) and cell volume (cm^3/cm) correlations with the components.

When blood volume was calculated in cm^3/m^2 of body surface area the correlations with the components were in no case statistically significant.

19. A comprehensive form for systematic total definition of the individual. E. S. C. Handy, Oakton, Virginia.

The form has 8 panels of reference serving as an index and guide to record and documentation; and a ninth central panel for integration.

The 8 reference panels are entitled: I. Biological, II. Body form, III. Ethnic traits, IV. Physical environment, V. Activities, VI. Aptitudes, VII. Conditioning, VIII. Behavior.

Panels I to IV define the physical man; V to VIII define the cultural, social and psychological man. Each item defined within a panel has its symbol, which is used in indexing photographs, documentary material, records of interviews, observations or measurements.

Panel IX, Integration, facilitates systematic tabulation and cross-reference required in studying correlations, by means of the symbols standing for the items making up the 8 other panels. At the bottom of the Integration Panel is a chart for recording by means of the symbols the occurrence of traits characteristic of the *propositus* in parents and grandparents, and in children and grandchildren.

The form is believed to be capable of facilitating both pure research and the appraisal of personal qualifications of physique and temperament for either clinical or practical purposes.

20. Bio-chemical tests of the saliva as an index to endogenous factors. Naomi C. Turner, Forsyth Dental Infirmary, Boston, Mass.

Inter-personal differences exist at the bio-chemical level as well as the morphological level. ''Blood factors'' represent one group of bio-chemical differences which anthropologists are recognizing. Saliva too may serve as a ready fluid source for measurement of the bio-chemical differences.

Certain of these tests of the saliva lend themselves readily to work in the field as well as in the laboratory. The amount of salivary tryptophane is one such variable. The test requires only a calibrated test tube, sulfuric acid, glyoxylic acid and saliva. The intensity of the purple (red-violet) color formed is a function of the amount of tryptophane or similar indole containing molecule. Because there

exists an inverse relationship between dental decay and salivary tryptophane the test is of more than academic interest.

Under optimal dietary conditions the tryptophane level would be sufficiently high but in diets containing too little protein, protein whose amino acid balance is not optimum, or a disproportion between protein and carbohydrate components such as may occur in processed farinacious diets, the amount of tryptophane may be a deciding factor in dental decay.

At the present time it is known that dental decay is rare among certain ethnic groups and among people of certain racial origins; field testing for salivary tryptophane will determine the effect of the alteration of the native diet on this amino acid and may further point out the relationship of tryptophane to dental decay.

SYMPOSIUM IN APPLIED PHYSICAL ANTHROPOLOGY

Papers numbered 21 to 29 inclusive were contributions to a symposium which was arranged by the chairman, Dr. Francis E. Randall. Prof. E. A. Hooton of Harvard University was the discussion leader. The first 3 papers of the symposium dealt with medico-legal applications of physical anthropology. The remaining 6 papers dealt with engineering applications of anthropometry. Plans are being made for the publication of these papers.

21. Medico-legal aspects of the skeleton: I. Sex, age, race and stature. T. D. Stewart, U. S. National Museum.

Owing to the proximity of the FBI Laboratory to the National Museum the staff of the Division of Physical Anthropology has been consulted frequently regarding the identification of skeletal remains found under suspicious circumstances. In broadly summarizing this experience, emphasis is placed upon the need in this type of work for extensive experience in handling human skeletal material and especially documented material. Care must be taken to distinguish between certainties and probabilities. Also there is danger of becoming overconfident because relatively few of the medico-legal identifications are verified. The emphasis is placed on caution because it is important to the science of physical anthropology, just as it is to the FBI, that our trained workers do not make mistakes.

In connection with stature determinations it is pointed out that the available correlation tables and formulas still are based upon 100 or less French cadavers measured 60 years ago. The more extensive material available in this country needs to be worked up.

22. Medico-legal aspects of the skeleton: II. Related factors, as condition of interment, action of fire, reconstruction, etc. W. M. Krogman, Graduate School of Medicine, University of Pennsylvania.

In reporting to law enforcement agencies it is important to give them some estimate of conditions and duration of interment. This can be done best by an on-

the-spot study of the site of exhumation, for "primary" or "secondary" interment, disturbance, and so on. Study of the bones, especially sites of muscle and ligament attachments, will aid in the time problem.

The action of fire is an important problem. Here it is necessary to ascertain conditions of combustion, the combustible used, the intensity and duration of exposure to heat. Consultation with heating engineers is useful. Experiments of burning bones and teeth in electric furnaces are necessary. Degree of charring, calcination, etc., must be studied.

The restoration of soft tissues to give cephalo-facial details is increasingly coming to the fore. Here anatomist and physical anthropologist combine, as scientists, with the sculptor to give the restoration both verity and art.

23a. Anthropology in the U.S. Army reburial program. H. L. Shapiro, American Museum of Natural History.

No abstract.

23b. The processing of the Pacific unknown war dead. Charles E. Snow, University of Kentucky.

The processes outlined by Dr. Shapiro were all put into practice under nearly ideal conditions at the Central Identification Laboratory and Mausoleum located at Schofield Barracks, Oahu, T. H.

As Anthropologist for the American Graves Registration Service I served as a technician directing the processing of the unknown cases from the Pacific Theater. A well equipped, clean, light laboratory provides excellent photographic, chemical and fluoroscopic facilities. Well trained embalmer personnel carry out painstaking examinations and make the routine measurements and observations of each body. The age, stature and weight estimates are carefully assessed and any outstanding physical mark (healed fractures, mastoidectomies, etc.) are noted upon the records. All observable clues to identity, including the identification tag, dental charts, names, numbers, and/or initials, obtained from clothing marks, jewelry, issued equipment, etc. are systematically investigated. In some of the better preserved individuals it is possible to obtain fingerprints.

This laboratory procedure furnished necessary data for the Board of Review charged with the responsibility of identification. A high preponderance of the unknown cases are being thus positively identified. It was a very gratifying experience to demonstrate the practical application of anthropological procedures to such a cause.

24. Relative variability of anthropometric measurements. James A Gavan, University of Chicago.

During the recent Army Anthropometric Survey repeated measurements were taken on 6 subjects. The data were analyzed to determine what factors influence the consistency of measurements. The coefficient of variation was used as a measure of relative consistency and the following factors were found.

Size. The smaller measurements show higher variability simply because they are small.

Type of measurement. In anthropometer and caliper measurements there is little variability when the landmarks are easy to locate and pressure, if used, is against bony parts. The variability increases either when the landmarks must be palpated or when the observer must judge the amount of pressure to use. Among the tape measurements there was less variability when bony eminences were used in defining the position of the tape. The variability increased when the measurement was taken over soft tissue and when the landmarks were not defined in terms of definite points. The largest variability was found when the landmarks were defined in terms of previous measurements.

Number of observers and body build of subject. There is an indication that these influence variability, but the kind of information available for the analyses of these factors is not large enough to permit a definite appraisal of their effect.

It is clear that although a team may be more variable in some measurements than a single observer, the difference is small and probably would not be significant when thousands of individuals are analyzed.

25. Applied physical anthropology in Great Britain in recent years. G. M. Morant, R.A.F. Institute of Aviation Medicine. (Read by F. E. Randall.)

A review of the applications of anthropometry to Royal Air Force problems during the recent war is presented. The method of application of anthropometry to the development of clothing size is described in detail and several points are noted which should serve as a guide in the conduct of applied research in physical anthropology. Emphasis is placed on the experimental method in obtaining the best results. As a matter of academic interest a problem investigated incidental to the general overall field is described. This problem involves the matter of the supposed increase in adult statures in British males. Evidence is offered that this supposed increase is a result of maturation of British males at progressively earlier ages throughout the past 100 years, with the most marked decrease in the maturation age having occurred between 1920 and 1945.

26. Measurements of man for making machinery. Barry G. King, Aviation Medical Service, Civil Aeronautics Administration, Washington, D. C.

Current aircraft are not made to fit the man. As a consequence, pilots are required to adapt themselves to existing conditions and operate under serious handicaps. Within the last few years this problem has received some attention but little quantitative work has been completed.

The attention of physical anthropologists entering this field is invited to certain special requirements. These are concerned with (a) the relation of the usual postures assumed in operation of machine controls to those established as standardized, classical postures employed in anthropometry, and (b) the statistical treatment of the measurement data to insure adequate provision for a satisfactorily large part of the population.

The anthropologist should further be advised of 2 popular fallacies which have adversely affected progress in this field. The first, which is mentioned only because it is so frequently encountered by those working in biotechnological fields, is the postulate that there are ''natural movements'' or ''natural directions of

movement'' for the operation of machine controls. The second, which is related to the problem of statistical treatment of the data, is that design requirements should be based upon measurements of the ''average man.''

27. Anthropometry and apparel. Mansfield Lonie, Commodity Standards Division, National Bureau of Standards.

The talk cites examples of current use of anthropometric data in sizing items of apparel; explains how use of model forms has tended to lessen use of precise body-measurements; indicates the variety of size measurements and how anthropometric data have been used to reduce this variety. It also indicates the anthropometric data needed to complete comprehensive sizing systems for apparel; urges cooperative research by scientists, applied mathematicians and apparel technologists; and suggests how needs of industry can be determined. It also stresses the practical value of body measurement data in sizing work, and concludes by urging continuous research to provide a large amount of practical data for the clothing industry, and the depositing of the resultant data in a central clearing agency.

28. Present day anthropometry at Wright Field. H. T. E. Hertzberg, Aero Medical Laboratory, Wright Feld, Dayton, Ohio.

Anthropometric research at Wright Field is being devoted specifically to Air Force, Aircraft Engineering problems. Examples of these applications are presented and the methods of application are described. The various types of problems being investigated include dynamic studies of time and motion, and static studies of dimensional requirements of the human body under standard and non-standard conditions. A plea is made for a future academic requirement that anthropometric principles be made a part of the curriculum of engineering schools.

29. Anthropometry in the Quartermaster Corps. F. E. Randall, Office of The Quartermaster General. (Read by title.)

A brief review of the past uses of anthropometry by the Army is offered and several examples of the types of information provided in the Quartermaster Corps are described. The organizational method by which the anthropometrist can best serve the needs of the Quartermaster Corps is described. The roll of the anthropologist is one of mediation in that his primary duty, beyond collection of anthropometric data, is to organize them in such a manner that they may be utilized by equipment designers and, subsequently, by test agencies in the conduct of size tests of experimental equipment. The anthropologist benefits most in fulfilling his obligations by receiving current anthropometric data on new personnel especially in limited age groups. By use of current information, it is possible for the anthropologist to provide clothing tariffs for use in general procurement as well as in specific limited issues.

30. The incidence and distribution of alopecia prematura idiopathica in Europe. R. E. G. Armattoe, Lomeshie Research Centre, Londonderry.

The incidence of premature baldness is of perennial interest though its etiology is still wrapped in mystery. The results of investigations carried out in the last 3

years in Switzerland, Great Britain and Sweden are here presented in the hope that other workers may thereby be stimulated to undertake similar studies either in endocrinology or in gerontology, for baldness is one of the signs of decreased endocrine function and the first stage in the progress towards senility.

In very few instances, namely about 5%, is this condition familial.

In Switzerland nearly 52% of all male intellectuals are bald headed; and of these 30% show frontal and the rest central or top baldness.

In Great Britain during the recent meeting in 1947 of the British Association for the Advancement of Science in Scotland, the writer found that 55% of all male delegates showed central baldness, 22% frontal baldness. Of the women delegates, over 58% showed definite hirsutism in the form of bushy moustaches. The ages of these women range between 21 and 45. These figures compare unfavorably with those of the normal population where the percentage is 6 between the ages of 22 and 75.

In Sweden females in State and academic employment showed no hirsutism whatever. Seventy per cent of young intellectuals showed frontal baldness beginning from the age of 26 to the age of 40. From 41 to 65 years of age baldness rises progressively till it covers the whole crown. Over 85% of the men in this last category are completely bald by the time they reach 50. In Sweden baldness exists in all classes but it is more noticeable among the intellectuals.

In France premature baldness is rare, the percentage falling in Picardy and the Paris region to as low as 5%.

In Ireland baldness has an occupational trend, affecting more those who work in confined areas or in chemical industries such as plasterers and plumbers, etc. It is interesting that solicitors are more affected than advocates.

It would appear from our work at this Centre the hirsuties is on the increase among modern cultured women and girls. Further investigations, in which we have invited the public through the Press to cooperate, are in progress.

The occupational and psychological handicaps against bald young men anxious to seek employment are real and any effort to understand and check this condition or to explain its real nature would be a decided help in our modern competitive society.

31. *An estimate of the number of genes in man.* J. N. Spuhler, Ohio State University. (Introduced by G. W. Lasker.)

Estimates now available on the number of separate gene loci in man are based on argument by analogy from *Drosophila*. These arguments employ a single human datum, chromosome number. They suggest man has 4 to 6 times the gene number of the fruit fly (where published estimates vary by a factor of about 6.5), that is, a minimum of 8,000 to a maximum of 78,000.

This paper outlines 2 approaches to the problem of gene number using additional data specified on man. Individually neither approach is fully satisfactory. Together they provide an interesting approximation.

1. In *Drosophila* the total haploid chromosomal length with the X is about 6.85×10^{-4} cm. Assume the fruit fly has 5,000 genes (salivary chromosomal data): each gene would occupy an average of 13.7 units of this length. The total haploid length in man, at a roughly comparable stage, is about 58.46×10^{-4} cm. Letting

human and *Drosophila* genes occupy the same mean chromosomal length, man would have a little over 42,000 genes.

2. The notion of lethal mutation permits a second estimate. Assume 20% of all conceptions terminate in non-viable offspring. Among these assume an excess, E, of males by 4% (of all conceptions) due to lethal mutations in the non-homologous portion of the X — the chief chromosomal differential (together with the relatively small, non-homologous region of the Y) between individual males and females. Statistical evidence strongly indicates the presence of such sex-linked lethals in man. If each locus in the non-homologous part of the X mutates to lethal at a rate, r, of 1 in 50,000 conceptions (the approximate mutation rate for the normal sex-linked gene to its allele for hemophilia), then the number of loci, n, in the non-homologous portion of the X, is given by $n = rE = 2{,}000$. The ratio of the non-homologous section of the X to total haploid length in man is of the order 1:17. On the basis of these speculations there are then some 34,000 gene loci in man.

Two independent approaches for estimates made here suggest the number of gene loci in man is of the order 34,000 to 42,000.

32. Dental occlusion in a pair of twins. Gabriel Lasker and H. H. Reynolds, Wayne University College of Medicine and University of Detroit School of Dentistry.

A pair of 35-year-old male twins were examined and shown to be monozygous by various criteria: general appearance, pigmentation, hair patterns, details of facial and dental morphology, ABO, MN and Rh blood tests, taste reaction to PTC, and finger and palm dermatoglyphics. One of the twins has a bimaxillary protrusion involving upper incisor jut and deep bite. It is associated with a burn of the neck, the scar contracture of which for 31 years has exerted a mechanical pull on the mandible. A simple functional explanation of the malocclusion seems probable but the situation is complicated by the fact that the co-twin shows some tendency toward the same type of occlusion and he has lost an upper molar, absence of which may have contributed to the differences observed.

33. A study in familial cephalo-facial growth pattern. R. M. Snodgrasse, Graduate School of Medicine, Division of Dentistry, University of Pennsylvania.

To determine the bearing of the course of growth on dental malocclusion, serial measurements of cephalo-facial length, heights, breadths, and depths together with certain bodily dimensions are routinely taken on the majority of patients accepted by the Orthodontic Clinic of the Graduate School of Medicine at the University of Pennsylvania. A case is presented in which a number of dimensions of a pair of presumably identical twins show extensive similarity and occasional near identity. Several measurements for the twins and other members of the family show a similar pattern of deviation from the standards with which comparisons are made. Considering that nutritional, medical, dental, hygiene (including oral habits) standards of this family are apparently satisfactory, consequent to the superior socio-economic level of the family, the importance of familial heredity in the perpetuation of the pattern is underscored.

34. Body measurements in the light of familial influences. W. W. Howells, University of Wisconsin.

This is an attempt to get a fresh approach to the relative behavior, and relative worth, of certain standard measurements used in anthropometry. Pairs of brothers were measured (ca. 95 pairs), and their differences were compared with the average differences of pairs of individuals selected at random from the same total group. Supposing that common heredity and environment should cause the brother pairs to differ less than the random pairings, would this tendency be expressed to a similar degree in all measurements, or would some measurements seem more susceptible to these influences than others?

The mean difference between brothers was in all cases less than that between individuals randomly selected, and less than the expected mean difference (which can be calculated from the standard deviation of the total sample). However this differential was proportionately considerably greater in some measurements than others. Similarly, the difference in variability, when tested by the f test, attains a 1% level of significance in somewhat more than half the measurements. There is some agreement as to which measurements show the greatest or least differences from the expected, random pattern; brothers are much more alike in stature, total face height, lower arm and leg lengths, cephalic index, minimum frontal diameter, and certain other features; while the influence of brotherhood appears slighter in the body and facial breadths generally, especially biacromial, bizygomatic and bi-iliac.

35. The measurement of obesity in children. Earle L. Reynolds, Fels Research Institute, Yellow Springs, Ohio.

A series of children and beginning adolescents from the Fels Research Institute were ranked with reference to degree of obesity shown, as measured by 5 different criteria: weight; weight/height; total fat, defined as total x-ray breadth of fat pads in 6 areas of the body; total fat/weight; total fat/height. Each ''obesity criterion'' is examined as to its effectiveness in picking out children who can be considered actually obese. For this purpose, obesity is defined as excessive weight for the age-sex group of the child, with evidence that this over-weight is derived principally from excessive fat, as distinguished from overweight derived from an excess amount of fat and/or other tissues. At the same time, it is suggested that children who are not absolutely overweight, but whose distribution of fat tissue is excessive in terms of their other tissues, be given special study. Such children are not considered in the usual clinical studies of obesity.

36. The standardization of morphological observations on the skull. Georg K. Neumann, Indiana University.

The problems of standardization of observations are much like those dealing with the standardization of measurements, except that the personal error tends to be greater in describing morphological traits because of the lack of definite landmarks. It consequently varies greatly with the experience of the observer. But more than in case of measurements, morphological data have been collected with-

out deciding beforehand exactly what the problem consists of. The field covered by routine observation blanks is entirely too great; it covers problems of function and other environmental factors, sexual and age determination, data usable for the determination of the mechanics of inheritance, as well as descriptive material for taxonomic purposes. If it is taxonomic, the observations involving higher categories should be separated from those that are of aid in tracing evolutionary relationships within the species *sapiens.* Fully half of those traits that have wider phylogenetic significance are presence or absence traits; attributes of specific and subspecific import are few; and those on the varietal (race) level are traits that deal mainly with form. In the construction of a series of scales, the writer has emphasized the latter aspect. After determining the total range of variability of the characteristics that in combination are of diagnostic value in separating recent man into varieties, convenient gradations have been illustrated in line drawing scales that should indicate closely what the investigator intends to express quantitatively by descriptive terms.

37. Considerations of stature and weight of the male, White American soldier. Francis E. Randall, Office of The Quartermaster General.

Studies conducted in the office of The Quartermaster General have produced data which may enlighten the knowledge involved in contemporary American human biology. Of particular interest to physical anthropologists is the relationship of the developing American male to his non-American ancestors. Approximately 25,000 men were studied in regards to their stature and weight as reflected by 4 different categories of American citizens. These categories are comprised of (1) Old American (all 4 grandparents born in the U.S.), (2) First generation Americans, (3) Second generation Americans, and (4) Mixed generation Americans of mixed origins. The statures and weights of these 4 categories are contrasted and compared and a conclusion is reached that the American male, as he progressively develops from his non-American ancestors, appears to be intermediate in stature and somewhat lighter in weight than the composite groups from which he is derived.

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GENETICS OF OSTEOCHONDRODYSTROPHY.— Quite different from chondrodystrophy [of genotypical nature, transmitted as a dominant character, arising rather frequently through mutation] is osteochondrodystrophy, Silfverskiöld-Morquio's disease, which is characterised by multiple disturbances in the anlage of the epiphyses, irregular ossification in the primary and secondary centres of ossification, and decreased growth. Recent investigations (Helweg-Larsen and Trier Mørch) have, however, shown that osteochondrodystrophy has to be divided into two forms:—

1. Morquio's syndrome, which is inherited as a monogenic recessive, and in which the skeletal changes are localised largely in the vertebral column.

2. Silfverskiöld's syndrome, which is transmitted simply as a monogenic dominant character, and in which the skeletal changes are localised particularly in the extremities. So far it has not been possible to calculate the mutation rate for Silfverskiöld's disease. Tage Kemp. Hereditary malformations in man. Heredity, vol. 1, no. 3, 1947, pp. 259–267.

RACIAL DIFFERENCES IN SICKLEMIA.— The incidence of sicklemia is high in the Negroid ethnic group. Evans found a sicklemia index of 28.3% in Gambian Negroes and a significant difference among some African groups. In Caucasians very few cases have been registered, the majority without sufficient documentation to dispel the hypothesis of miscegenation. . . . In Brazil, where the number of Negroes, Mulattoes, and Cafuzoes is high, the percentage of sicklemics is considerable. Sicklemia has not been found in white Brazilians surely free from Negroid mixture.

. . . among 1,379 full-blooded [Brazilian] Indians, of which 172 were crossing intertribes, no sicklemics were found. Three sicklemics among 166 Fulniô Indians (Aguas Bellas, State of Pernambuco) have been observed. However, this tribe is very mixed with Negroes and Mestizos. . . . These data indicate that the sicklemia test may be useful as an auxiliary test in anthropology. — E. M. da Silva. Absence of sickling phenomenon of the red blood corpuscle among Brazilian Indians. Science, vol. 107, no. 2774, February 27, 1948, pp. 221–222.

THE MAKAPANSGAT PROTO-HUMAN AUSTRALOPITHECUS PROMETHEUS

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SIX TEXT FIGURES AND ONE PLATE

The deserted dumps, at the limeworks on the farm Makapansgat, 13 miles northeast of Potgietersrust in the Central Transvaal, have been the object of concerted study during the past 3 years by students and members of the staff from the Anatomy Department of the University of the Witwatersrand. Many primate and other mammalian fossils have been collected and identified. Considerable deposits of bone breccia remain embedded in the abandoned caverns; so we have correlated the dumped material found outside with the stratification exhibited in the workings.

The fossils from the basal gray fossiliferous stratum of the limeworks include several baboons characteristic of the Plesianthropus horizon at Sterkfontein; viz. *Parapapio broomi* Jones, *Parapapio jonesi* Broom, and probably *Parapapio whitei* Broom. It has also yielded 14 species of Bovidae, 8 of which appear to be new (vide L. H. Wells, in press); 3 carnivores (viz. lion, hyaena and jackal), 2 extinct pigs, rhinoceros, hippopotamus and finally 2 representatives of the giraffe family (including the extinct *Griquatherium*). The fauna is consequently late Villafranchian (or early Pleistocene) in character.

The Bernard Price Foundation for Palaeontological Research in the University of the Witwatersrand has maintained a party in the area since March, 1947, to excavate systematically the Cave of Hearths a mile further up the dolomitic

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valley. In their spare time the 3 brothers Kitching, James, Ben and Schepers, members of this excavation party, have continued our sustained search of the dumps. Towards the middle of September, the eldest, James, extracted from a characteristic piece of the basal gray stratum the long-awaited proof that it is an australopithecid bone breccia (vide plate 1 and text figs. 1, 2 and 3).

The importance of the discovery, apart from extending the range of this proto-human group 200 miles to the north-east, is firstly its affording the earliest detailed information of the back of the skull, secondly its showing that the occiput is in some respects the most significantly human of all the bones in the australopithecid skeleton, and thirdly its proving that some of the australopithecids were not only big game hunters but were also acquainted with fire.

Owing to partial synostosis of the sagittal and lamboidal sutures this calvarial fragment comprises the major portion of the occipital bone, including most of the right margin of the foramen magnum and the posterior third of each of the parietal bones. Several very significant features — e.g. increased thickness of the cranial vault, expanded planum occipitale, inferior situation of the inion relative to the opisthocranion and consequent downward deflection of the planum nuchale, the existence but moderate development of a torus transversus occipitalis, and the presence of a sutura transversa occipitalis (or sutura mendosa) with subsidiary sulci forming a complex "Inca" bone, — differentiate this occiput anatomically from those of anthropoids and distinguish them as human.

Firstly its general bony thickness (6.0–13.0 mm) is approximately intermediate between that of the chimpanzee (4.0–7.0 mm) and *Sinanthropus* (8.0–15.0 mm).

Secondly, although the temporal muscles were massive enough to clothe virtually the entire surface of the parietal bones posteriorly — and consequently the clearly defined superior temporal lines are separated from one another at the sagittal suture region by an interval of not more than 5 mm

(and perhaps fused further forward in the vicinity of the vertex) — the parietal bones have been so widely divaricated posteriorly by the occipital bone, that the sagittal length of the planum occipitale in the chimpanzee (49 mm) has been increased by the astonishing amount of more than 50% in *Australopithecus* (78 mm). The temporal and nuchal muscles in the gorilla, and especially in the male, are so massive that sagittal and lambdoidal crests rise up in triradiate fashion between them and the gorilloid occiput becomes completely clothed by these muscles. In the chimpanzee, and especially in the female, the temporal muscles may be so reduced that not only is there no sagittal crest and a lambda freed from this muscular covering but a considerably greater portion of the dorso-medial portion of the parietal bone may be laid bare than is exposed in this adult *Australopithecus.*

This process of laying the skull bare from, or failing to cover it with muscles — (other than the occipito-frontalis muscle sheet and its galea aponeurotica attached to the highest nuchal line, which here assumes an arcuate outline)— can be happily expressed by designating this highly significant, but hitherto unnamed area of the skull, "the bare area of the skull;" and by denominating that part of it occupying the squama occipitalis and lying between the superior nuchal lines and the lamboid suture, "the bare area of the occiput" (vide plate 1). This bare area of the occiput, which is nonexistent in the adult male gorilla and reached the rhomboidal size of ($\frac{L \times B}{2} = \frac{20 \times 30}{2} =$) 300 mm² in a female chimpanzee (in the Pretoria Museum collection), attains the triangular dimension of ($\frac{L \times B}{2} = \frac{55 \times 76}{2} =$) 2140 mm² in our adult *Australopithecus.* The effects of this "7-fold" expansion of the australopithecid occipital bare area relative to that of the chimpanzee are not confined to the exterior; they are reflected on the interior aspect of the occipital bone.

The cerebral surface of the occipital bone in *Australopithecus* approximates that of a spherical quadrant with a diameter or width of 80 mm (viz. 5030 mm²). The internal cerebral surface of an adult male chimpanzee occipital bone

(from the Museum of the Dental Hospital of this University) merely displays a flattened triangular area of scarcely more than ($\frac{L \times W}{2} = \frac{27 \times 64}{2} =$) 864 mm.^{2} In other words the chimpanzee has a cerebrum whose occipital lobes, insofar as they are covered by the occipital bone, display only ⅙ of the area found in *Australopithecus* (vide text fig. 5).

The 3rd feature differentiating this occiput simultaneously from those of living anthropoids and even from those of primitive hominids, is the inferior situation of the inion relative to the opisthocranion (vide plate 1).

In anthropoids the whole or major part of the squama occipitalis has been invaded by the powerful nuchal musculature to afford as extensive an area of attachment as possible; and thus the inion (or external occipital protuberance) is carried up above the opisthocranion until it lies slightly below, or coincides with the lambda. Similarly the superior nuchal lines lie well above the opisthocranion level, and approximate or fuse with the superior temporal lines on each side to form the lambdoid crest. In *Pithecanthropus, Sinanthropus* and *H. soloensis* there is no crest but the occipital torus forms an elevated bony ridge running transversely across the bone. The torus is so massive that a broad groove, the supratoral sulcus, demarcates it from the planum occipitale; the ridge is at its thickest in the mid-line and is so broad that the inion and opisthocranion coincide.

In *Australopithecus* also there is no crest but a torus occipitalis, which lies well below the opisthocranion; the bone is thickened across its entire width but the "torus formation" is so generalized that it causes no irregularity of the external contour in the central part of the bone. The lateral halves are boldly marked, tolerably broad, and separated by a supratoral sulcal cleft (4 mm at its deepest part) from the occipital plane. The end result is that the width of the nuchal plane of the occipital bone in *Australopithecus* is appreciably less (85 mm) than the probable maximum parietal width (126 mm approx.) whereas in the chimpanzee these relationships are reversed. Consequently the nuchal plane in *Australo-*

pithecus occupies about three-quarters of the area it covers in the chimpanzee.

Weidenreich ('43) rightly insists that there is no true equivalent of the human occipital torus in anthropoids. He regards the occipital torus as the post-otic part of a general reinforcement-system demanded by human, as contrasted with anthropoidal calvarial architecture: due perhaps (though he does not suggest this) to the utterly different masticatory carnivorous habits of man. The prominent development of this reinforcement-system (of which the torus occipitalis forms part) in *Pithecanthropus* and *Sinanthropus* and its progressive tendency towards disintegration in *H. soloensis, H. neanderthalensis* and *H. sapiens* caused Weidenreich to find "no reason why the Neanderthalians should not be considered intermediate forms between primitive types like *Sinanthropus* and *Pithecanthropus* on the one hand and *Homo sapiens* on the other" (pp. 243–244). But the inferiorly placed inion and the moderately developed occipital torus of this adult *Australopithecus,* which is more primitive than, and whose cranial cavity is scarcely as great as that of *Pithecanthropus* invalidate Weidenreich's premise (p. 242) that "the decomposition of superstructures such as frontal and occipital tori go hand in hand with the expansion of the brain." The occiput of *Australopithecus* shows that an excessive torus occipitalis is not a primitive paedomorphic trait but an emblem of gigantomorphic specialization in human cranial morphology (vide text figs. 1–4).

The low placement of the inion in *Australopithecus* connotes improved balancing of the head upon the vertebral column. Along with other infantile lineaments rendered possible by the protracted infancy characteristic of human beings, the inferiorly localized inion is an illustrative instance of the general principle of "paedogenesis" which was first enunciated by von Baer (1828); and restated (vide Gregory, '46) in somewhat different terminology but with the same general meaning as "neoteny" by Kollmann (1882), "paedomorphosis" by Garstang ('22), and "foetalization" by Bolk ('26).

Versluys ('39) was the first to recognize that this principle of retardation was applicable to *Australopithecus*. Its significance for human physical and cultural evolution was clearly enunciated by Bolk ('17 and '26) and Briffault ('27).

In terms of paedomorphosis, as de Beer ('38) insists, the embryonic undeveloped ancestor resembles the adult descend-

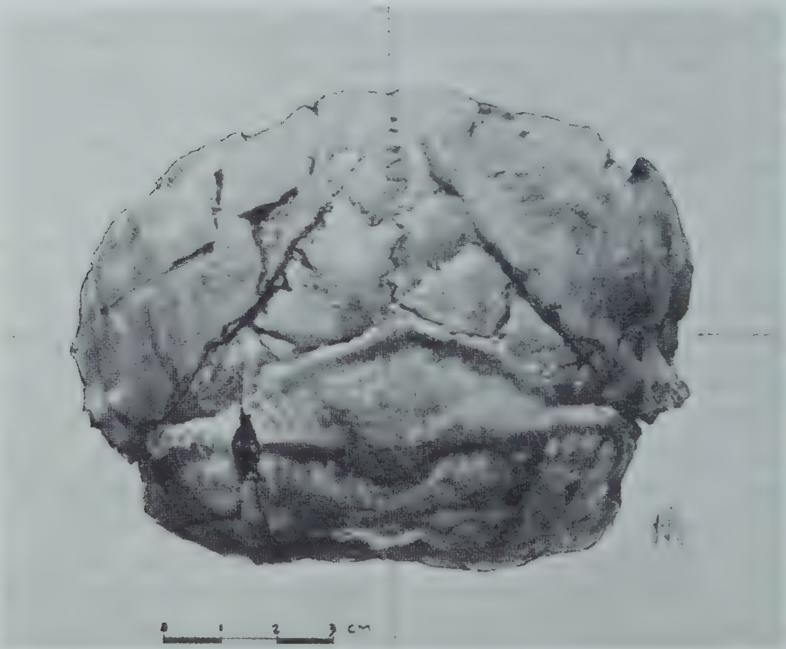

Fig. 1 Occiput of *Australopithecus prometheus* in norma occipitalis for comparison with the photographs in plate 1, and to illustrate the detailed anatomy of the expanded planum occipitale.

ant. The recapitulation theory taught the reverse doctrine, viz. the embryonic descendant resembles the adult ancestor. *Australopithecus*, as opposed to *Pithecanthropus* and *Sinanthropus* affords numerous examples of how "embryonic variations of persistencies became the leading features of subsequent evolution" (vide Dart, in press). The retention of the inion virtually midway between opisthion and opisthocranion is a paedomorphic retardation, which has peculiar postural

significance: it confined the nuchal musculature below the skull and excluded it from the rear (vide text figs. 1–4) Consequently *Australopithecus* retained the nuchal plane at an angle inclined only 26° to the horizontal. The same angle in a Bush skull measured 16°, in a European 20° and in a Bantu (Fingo) 31°. In *Sinanthropus* it rises to an inclination of 42°, in the chimpanzee to 60° and in the gorilla to 70° or more, i.e. almost a right angle. In this crucial matter of the slope

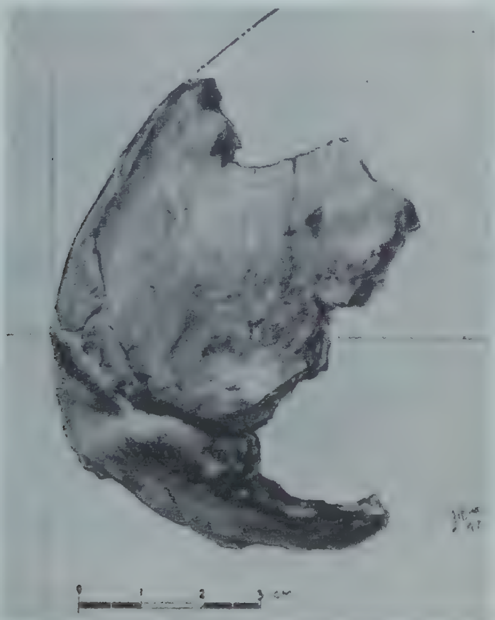

Fig. 2 Occiput of *Australopithecus prometheus* in norma lateralis to illustrate the human contours of the planum occipitale and the planum nuchale.

of the nuchal plane *Australopithecus* is diametrically opposed to the apes and is much closer to modern man than are *Pithecanthropus* and *Sinanthropus*. As Weidenreich says ('43, p. 96) "In modern man . . . the contour of the neck turns forward beneath the opisthocranion. Such nuchal incurvation did not exist in *Sinanthropus*: his conditions rather resemble those of the great apes which, however, were certainly more bull-necked."

In *Australopithecus* the nuchal muscular impressions differ from those of anthropoids and resemble those of modern man. The nuchal plane is delimited by a pair of superior nuchal lines arching anteriorly over the generalized thickening of the torus to coalesce at the midline in a small, slightly elevated, and almost triangular external occipital protuberance. An almost linear external occipital crest, providing attachment for a delicate nuchal ligament, links the protuberance with the foramen magnum. From the crest run laterally the 2 slender, but strongly arched inferior nuchal lines delimiting

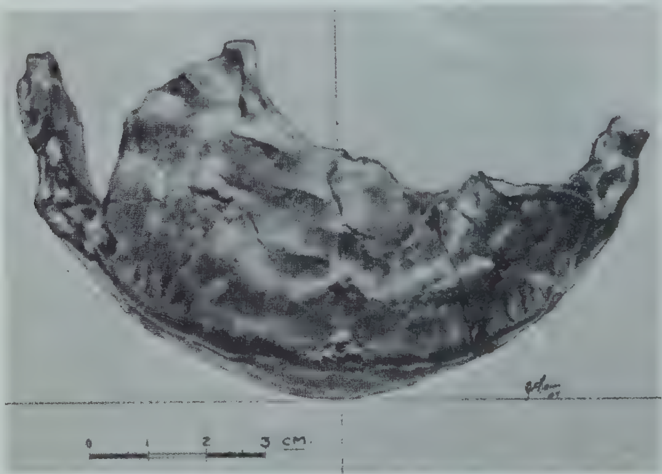

Fig. 3 Occiput of *Australopithecus prometheus* in norma basalis to illustrate the detailed anatomy of the rounded and contracted planum nuchale.

the insertions of the recti capitis (vide text fig. 3). The narrowed and antero-posteriorly restricted fields of attachment for the nuchal musculature implied by the foregoing anatomical facts betoken a vertical body carriage and a tapering slenderness of the nape of the neck, and therewith a body stature and cranial flexibility such as typifies the pygmoid Bushman; and in absolute contrast with the slung-head and slouching semi-erectness of the great apes on the one hand and the stooping head-carriage and bull-necked muscularity of *Sinanthropus* and *Pithecanthropus* on the other hand.

The external surface of the virtually complete *Plesianthropus* cranium (recovered at Sterkfontein early this year and kindly made available by Dr. Broom for comparison), proved so friable during development that the precise situa-

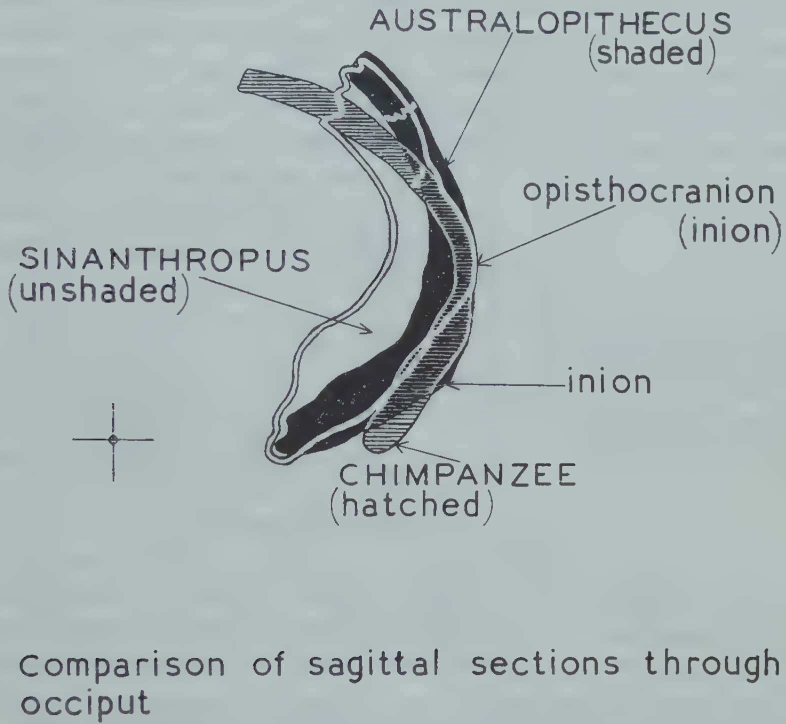

Fig. 4 Sagittal sections through occiputs superimposed to illustrate the divergent anatomy in this region of *Australopithecus*, *Sinanthropus* and a female adult chimpanzee. The opisthocranion of *Australopithecus* has been superimposed upon the opisthocranion (inion) of *Sinanthropus* and the inion of the chimpanzee, in which in this particular instance the "opisthocranion" is situated 1.0 mm anterior to the vertical plane dropped from the inion when the chimpanzee skull is oriented on the Frankfort horizontal plane.

tion of its temporal lines is uncertain. That small-brained (circa 450 cm^3) australopithecid skull exhibits, however, a prominent torus occipitalis (7.0 mm high and 4.0 mm broad), which runs as a ridge across the bone, its sharpness being emphasized by the flattened and even scalloped condition of

the squama occipitalis above it. *Plesianthropus* therefore possesses a torus, a supratoral sulcus and an opisthocranion-inion which, though human in type, is closer in general morphology to those of *Sinanthropus* and *Pithecanthropus*. In consequence the distance between the opisthocranion and opisthion in the Makapansgat *Australopithecus* is 57 mm as against 34 mm in *Plesianthropus*. These discrepancies between the 2 types despite their occurrence in comparable geological horizons are best exhibited by the series of comparative measurements in the accompanying table:

	CHIMPANZEE	PLESIANTHROPUS	TAUNGS	MAKAPANSGAT	PITHECANTHROPUS
Internal occipital arc	49	52	60	70	75
External occipital arc	65	72	68	78	87
Greatest parietal width	94	95	100	126	134
Endocranial width [1]	94	98	98	103	117
Endocranial height [1]	65	66	71	77	86
Max. cerebellar width [1]	75	75	74	76	86
Coronal endocranial arc [1]	134	133	158	168	197

[1] Measurements taken opposite to the temporo-cerebellar notch.

The 4th human characteristic of this occiput is a typical sutura mendosa. It runs transversely from one asterion to the other above the opisthocranion and the distinctly arcuate highest nuchal line, with several little Wormian bones intercalated between it and the sutura lambdoidea on each side and a large "Inca" bone in the center. This central "os Incae" was subdivided into 4 (probably originally 6) parts by accessory, sagittally and diagonally-running sutures (vide text fig. 1 and plate 1).

In a small percentage of living human beings of all races Wormian ossicles appear usually along the course of lambdoid suture and occasionally in the site of the posterior fontanelle as a true interparietal bone. Such a genuine interparietal bone occurs as a rule in young anthropoids and unites, as in man, with the occipital bone; and Wormian bones may occur in the lambdoid suture of the chimpanzee

(Hooton, '42, p. 60). But "Inca" bones or ossa epactalia of the type described here, which occur relatively frequently in American Indian skulls where they were first noted, have never been found in anthropoids (vide Weidenreich, '43). In 4 of the 5 *Sinanthropus* skulls the apex of the squama is similarly separated from the rest of the occipital plane by a transverse suture. In 2 cases there is, as here, a sutura mendosa separating almost the entire upper scale of the squama; in the 2 others the accessory transverse suture is higher in position and the single "interparietal bone" occupies about half the height of the upper scale. None of the known Pithecanthropus skulls nor the primitive rhodesioid types of Ngandong *(H. soloensis)* have shown any indication of these truly supernumerary bones. Amongst the Neanderthalians, the skull of Saccopastore, described by S. Sergi ('44) exhibits a great number of Wormian bones in the lambda region but none of them reaches the size nor has the position of the Sinanthropus bones (vide Weidenreich, '43, p. 200).

The bare area of the skull, which owes its existence to the failure of the temporal and nuchal musculature to clothe completely its vertical and occipital aspects, provides a locus minoris resistentiae (during infancy and adolescence before the coronal, sagittal and lambdoid sutures coalesce, and particularly along these sutural lines of weakness) of which advantage is taken to accommodate the expanding human brain: this process we witness, as it were, in the flood-time of its initial "occipito-parietal" phase in *Australopithecus*.

More than 100 "Wormian" bones have been found in a hydrocephalic human skull. The predilection of supernumerary bones for the fontanelles and the lambdoid suture (which customarily is the last to become obliterated), their increased number in hydrocephalics and their frequency in races that submit infants to cranial deformation, support the idea that cranial tension during infancy provokes sutural ossification. This occipito-parietal system of sutural bones is, as in other human types, an unusual cranial growth in

Australopithecus that resulted from a cerebral expansion, "whose demands could not be fulfilled by the normal increase in size of the regular cranial bones" (vide Wood Jones, '46, p. 227).

These sutural ossicles also display the 5th hominid feature, namely, retardation of sutural obliteration. In living anthropoids not only do the sutures of the cranial vault commence to close very early, namely at the time of the eruption of the 2nd molar tooth (an age corresponding with that of early human adolescence i.e., 12 years); but the velocity of coalescence is also accelerated, complete closure being effected in early adult life (vide Krogman, '30–'31). *Pithecanthropus* resembles the anthropoids in having the cranial sutures fused at a much earlier age than is the rule in modern man; but none of the *Sinanthropus* skulls have their sutures completely closed and obliterated as have the Pithecanthropus skulls. The divergence in rapidity and completeness of sutural closure between these 2 primitive human types assumes new significance in view of the plastic sutural pattern exhibited by *Australopithecus*.

The order in which the cranial sutures of *Sinanthropus* fuse differs from modern man only in one instance: the coronal comes first and is followed by the sagittal, whereas in modern man this is reversed. In the type Plesianthropus skull (vide Le Gros Clark, '47) the preserved upper part of the coronal suture and the anterior half of the sagittal suture were still patent although this young adult, probably a male, had all 3 molars fully erupted and the 3rd comparatively unworn. We do not know which of the 2 sutures started closing in the Makapansgat specimen but the posterior half of the sagittal suture and part of the lambdoid sutural system has been obliterated internally. In modern man obliteration of the sutures begins on the inner surface about 10 years sooner than on the outer surface and may begin between the 30th and 40th years; and although the order, time and rate of the closure are all very variable, complete obliteration does not take place till an advanced age. From the state of wear of

the teeth in the infantile *Australopithecus africanus*, we know that it must have retained its milk dentition for a much longer period than living apes; and that, in consequence the australopithecid group enjoyed a prolonged infancy comparable with that characteristic of mankind. Commenting on this, Le Gros Clark ('47) further deduced from the evidence of differential attrition in the 3 lower molars of the Paranthropus jaw, "that in the sequence of the appearance of the permanent teeth, as well as in the length of the intervals between their eruption, the Australopithecinae probably resembled man and not the recent large apes."

The patency of the coronal and sagittal sutures in *Plesianthropus* also suggests "a more prolonged growth period in the Australopithecinae than is found in the modern large apes" (Le Gros Clark, '47). We can therefore be tolerably certain that this occiput despite its paedomorphism belonged to a mature adult of considerable age.

The comparative measurements cited show directly the 6th hominid feature, viz: that in respect of occipital expansion the Makapansgat specimen approximates *Pithecanthropus I*. Unfortunately the occiput was lacking from *Paranthropus*, but Dr. Schepers reconstructed several endocranial casts from the skull fragments available; and the horizontal contour of the endocranial cast of the Makapansgat occiput conforms with striking exactitude to the contour of the reconstructed cast depicted for *Paranthropus* (vide Broom and Schepers, '46). In height also the Makapansgat endocranial cast is much greater than that of *Australopithecus africanus* and corresponds with that of *Paranthropus* (vide text figs. 3, 4 and 5).

Hence the total endocranial volume of the Makapansgat skull was not less than that estimated for *Paranthropus*, viz. 650 cm^3 (i.e. equivalent to that of the largest known gorilla, and only 125 cm^3 less than *Pithecanthropus II*). As Schepers pointed out, if *Paranthropus* were an average specimen of its type, their brains would have fluctuated in volume from 490 cm^3 to 815 cm^3. On the other hand, if it be argued — as would be reasonable — from the lack of a massive torus

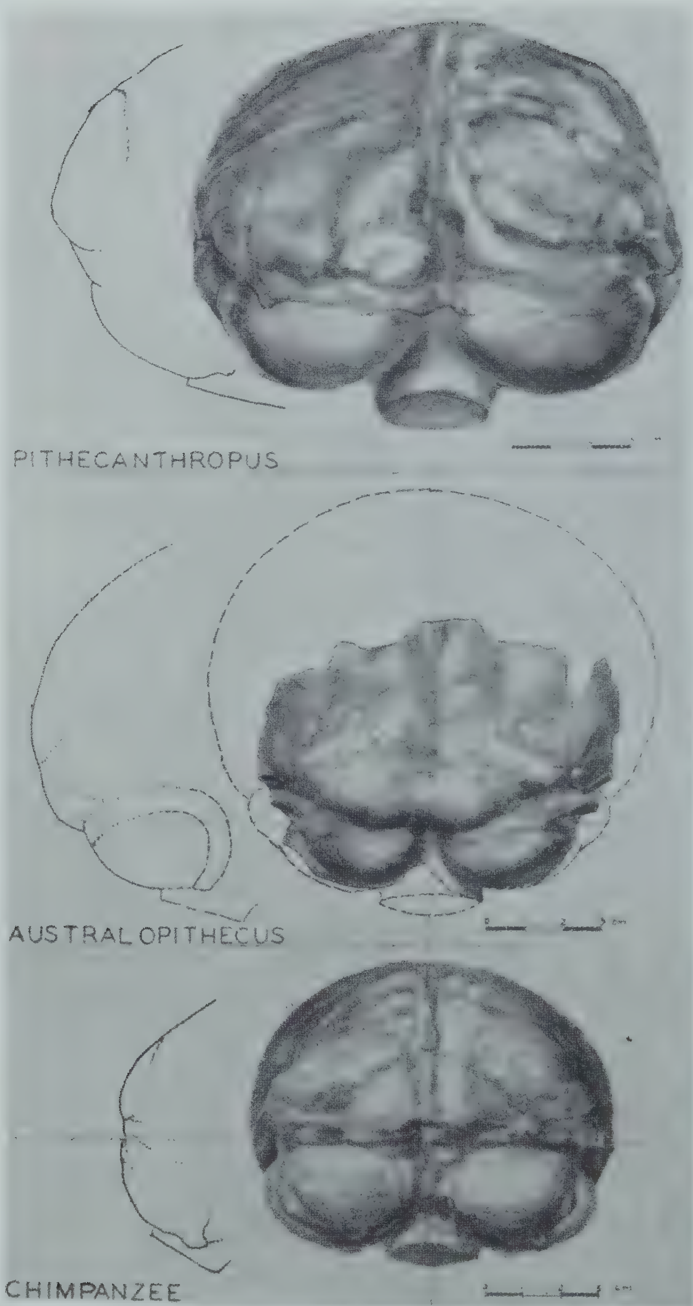

Fig. 5 Occipital views and lateral outlines of occipital regions of endocranial casts of *Pithecanthropus* (above), *Australopithecus* (central) and chimpanzee (below) to illustrate the humanoid increase in the relative proportions of cerebral to cerebellar matter in *Australopithecus* due to the vertical and dorso-lateral expansion of its parieto-temporo-occipital association areas.

occipitalis, that the possessor of the occiput from Makapansgat was female there is no escape from the corollary that males of the species possessed brains larger than some Pithecanthropids. Gorillas with brains of this order of magnitude, as Schepers said, "almost invariably weigh 400 to 500 pounds, being gigantic lumbering brutes"; whereas *Paranthropus* "was of low stature and, according to Dr. Broom, not more than 100 pounds in weight, probably weighing 80 pounds." Similarly it would be unreasonable to expect that the pygmoid Australopithecids even if more intelligent should exhibit brains as large as the big-limbed *Pithecanthropus.*

Despite the enlargement of the brain in the gorilla it only accounts for $\frac{1}{150}$ to $\frac{1}{200}$ of the creatures's body weight; whereas in modern man, who has about $\frac{1}{3}$ to $\frac{1}{2}$ the body weight of and $2\frac{1}{2}$ times as much brain weight as the gorilla, the brain accounts for $\frac{1}{50}$ of body weight (vide Hooton, '42). In *Australopithecus* the ratio of the brain weight to the body weight consequently came much closer to that of modern man than does that of the gorilla.

But where skull morphology and body-weight diverge as vastly as they do between the gorilla and *Australopithecus* it is absurd to institute direct comparisons with the gorilla. Consequently we have depicted (vide text figs. 5 and 6) the occipital view and sagittal and coronal contours in endocranial casts of an adult male chimpanzee and of the large Pithecanthropus I calvaria found by Dubois. These display, along with the foregoing figures, how the cerebrum and cerebellum of *Australopithecus* approximate more closely the pattern of those organs in modern man than do either of the other 2 (cf. text fig. 6).

The endocranial volume (520 cm^3) of the 6-year old Taungs infant postulated an adult endocranial volume equivalent to that of the Makapansgat adult; the endocranial cast of this adult occiput confirms and corroborates the evidence of cerebral expansion and intellectual superiority furnished over 20 years ago by the Taungs endocranial cast.

Despite the initial refusal of certain critics to accept the pre-human status claimed by the writer for *Australopithecus* in 1925, a growing number of scientists, such as Sollas, Adloff, Alsberg, Kleinschmidt, von Koenigswald and Arambourg, have since then spontaneously and independently claimed the type as in fact, already human. Each successive discovery of skull, limb girdle, and long bone fragment by

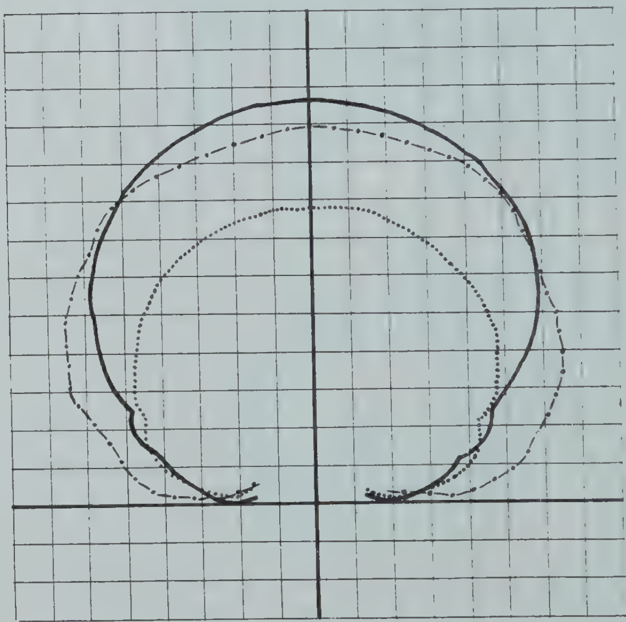

Fig. 6 Coronal contours at the widest parts of the endocranial casts of chimpanzee adult male . . . ., *Australopithecus prometheus* ——————, and *Pithecanthropus* —·—·—·—·—·—·—·

Broom has served to provide cumulative evidence of hominid rather than pongid structural characteristics in the Australopithecinae (vide Le Gros Clark, '47).

This occiput supports those distinguished advocates and these recent discoveries by demonstrating that, whatever small-brained species of the group may have existed, other species similarly pygmoid in size, but with ultra-simian and

quasi-pithecanthropid brain volume preceded, accompanied and succeeded them.

These several features we have discussed — the thickened skull with its paedomorphic torus occipitalis; the occipital bone with its expanded planum occipitale, sutura mendosa and parieto-occipital system of sutural ossifications; its low lying inion and elevated opisthocranion and reduced planum nuchale; the retardation of sutural obliteration and the concomitant expansion of the temporo-parieto-occipital association areas of the brain — constitute collectively a series of interdependent phenomena explicable only in terms of an evolutionary history divergent from that of apes but identical with that of man. Here we confront an assemblage of characters indicative of progress cerebrally, cranially, and posturally such as renders it indefensible to range the Australopithecinae with living anthropoids. On the other hand they are so closely related to modern man in crucial paedomorphic features where they differ from *Pithecanthropus*, that the admission of the Pithecanthropus group to the human "subfamily" would also be unjustified if the Australopithecus group were excluded. Thus the Makapansgat occiput vindicates Sollas' (vide Broom and Schepers, '46, p. 17) regret that the name given was not *Homunculus*. These Australopithecids actually represent pre-palaeolithic man in his various forms at the threshold of the Pleistocene period in South Africa.

The special significance of the Makapansgat valley limeworks deposits in unravelling these early human mysteries lies in their being true hearths and thus providing information, that hitherto has been lacking elsewhere in South Africa, concerning man's hunting skill, his probable weapons and his use of fire.

Twenty-two years ago a charred and comminuted ungulate bone breccia of the same sort, forwarded from the same site by a local school-teacher (now inspector of education), Mr. Wilfred I. Eitzman, caused me to initiate steps to prove his and the limeworkers' suspicions that the breccia was the handi-

work of man. Selected pieces were sent to the late Dr. James Moir of the Government Chemical Laboratory in Johannesburg and to Dr. F. W. Fox of the South African Institute for Medical Research. Both of these competent chemists carried out analyses and reported the presence of numerous black particles resembling carbon in the dried acid-insoluble residue and the transformation of most of this black material into carbon dioxide. The presence of carbon having thus been demonstrated the material was claimed in a brief and unwittingly prophetic note to the South African Journal of Science (1925) as coming from a primitive human hearth. It was not until the lapse of 2 decades when a party of our students organized by Mr. P. V. Tobias brought back from a biological excursion to this valley in 1945 further pieces of this breccia — and 1 containing a baboon belonging to the same Parapapio species, which had been extracted from the Sterkfontein breccia by Mr. Trevor Jones ('37) another of our students 9 years previously — and named by him with corresponding prescience after Dr. Broom — that the potential association of the previously described hearths with an *Australopithecus* provoked further investigation.

The unremitting search through tons of breccia conducted since that time, as reported to the Pan-African Congress in Prehistory at Nairobi last January, has failed hitherto to lay bare any trace of intentionally-fashioned stone implements with a cutting edge or point in this ancient stratum; but numerous smashed skulls and split long bones have been found. They belong, as stated at the outset of this note, to practically every type of big game characteristic of the eastern riverine savannah as contrasted with that of the western desert fringe in southern Africa. Detailed chemical analyses of glassy and ashy materials and microscopic examination of these fluxes, ashes and charred bones during the past 2 years have furnished Dr. V. L. Bosazza (who until recently was assistant chemist at the Olifantsfontein potteries of the Consolidated Rand Brick, Pottery and Lime Company), with ample corroboration of the conclusions, previously arrived at

by Drs. Moir and Fox about the systematic use of fire by these primitive troglodytes. Lastly a detailed re-examination performed during the past year of every available fossil baboon from Taungs, Sterkfontein and Makapansgat, in which task I had the valued expert assistance of Dr. R. H. Mackintosh, our Professor of Forsenic Medicine, has confirmed and extended to all these sites conclusions of manual dexterity on the part of *Australopithecus* previously arrived at from the study of the Taungs baboons alone. The vast majority of these baboon skulls show localized fractures which must have been produced by well-aimed blows on the head with some sort of weapon. This re-examination has further revealed that the blows in addition to being well-aimed from the front, side or rear, were frequently very powerful. They were also delivered from above in a downward direction and frequently by clubs or bludgeons which caused at the sites of impact a double-furrowed or double-fractured impression. Such duplicate indentations could have been caused only by an object with a double-ridged end, such as the posterior aspect of the distal extremity of the humerus of the larger ungulates. Long bones of this type, encountered in the Makapansgat limeworks' gray layer, frequently show that, in addition to being split open, these ridges or their ends were cracked and broken off prior to fossilization; although the distal extremities of the bones were obviously of little value for their bone marrow content. These carnivorous hunters were therefore familiar with the use of fire and bludgeons and apparently used crude long bones as implements in similar fashion to *Sinanthropus*. Some of the penetrating puncture wounds which are also found may have been caused by the dagger-like horns of antilopes, and it is noteworthy that up to the present ungulate heads retaining their horns intact have also never been found in the dumps.

Practically all australopithecid skulls discovered display, like the baboons and the big game, evidence of having succumbed to major cranial violence, as was pointed out independently by Dr. Schepers (Broom and Schepers, '46). Nor

is the present occiput an exception: it had been detached from the rest of the skull before fossilization. In respect of cannabalism these proto-human folk resembled *Pithecanthropus, Sinanthropus* and the rhodesioid primitives of Ngandong. These intelligent, energetic, erect and delicately-proportioned, little people, were as competent as any other primitive human group in cavern life made comfortable by the use of fire, in the employment of long bones as lethal weapons, in the cunning and courage of the chase and in internecine strife. They had conquered the most formidable beasts of the field; they were already in the toils of an ever accelerating evolutionary process occasioned by their intellectual struggle with the forces of nature and with their fellows.

Broom has deduced (Broom and Schepers, '46) from faunal divergences that the Taungs Australopithecus deposit belongs to a geological horizon considerably more ancient than that of the Sterkfontein Plesianthropus. The Makapansgat occiput demonstrates that an equally large-brained australopithecid inhabited the Central Transvaal while *Plesianthropus* occupied the Southern Transvaal. If, as Broom suggests, *Paranthropus* comes from a still later horizon at Kromdraai, large-brained australopithecids were characteristic of all 3 geological horizons; viz. Taungs, Sterkfontein (Makapansgat) and Kromdraai. There is a possibility but a rather remote one, in view of the divergences between the baboon at the 2 sites, that the faunal differences between Taungs and Makapansgat (or Sterkfontein) could be an impression of climatic rather than geological discrepancy. In that event we might be confronting at Makapansgat merely the adult form of the large-brained *Australopithecus africanus.* But the Taungs infant had an uncomplicated occipital sutural system and it seems more probable that the *Australopithecus* of Makapansgat, although closely akin, was a different species from that of Taungs; he certainly hunted bigger game and had a more varied dietary. Even if there were none of these differences the locality and the novel evidence it affords would

justify reference of the specimen to a new species: *Australopithecus prometheus.*

Weidenreich ('43, p. 245) says "Since the name *Sinanthropus* implies a different genus, according to the rules of the taxonomists, this name should be dropped and replaced by the name *Pithecanthropus";* and he goes on to point out that in view of their morphological similarity the name *Sinanthropus pekinensis* is without "generic" or "specific" meaning and has only "locality" significance; it is merely a "latinization" of Peking man. When the Taungs infant was described I thought its differences from man and from anthropoid would justify the creation of a new family for its reception; but when the mammalia were reclassified 20 years later (Simpson, '45) the 2 previously accepted families of Pongidae and Hominidae were reduced to "sub-family" rank in a single enlarged family, the Hominoidea.

At the outset Broom described the small-brained *Plesianthropus* as *Australopithecus transvaalensis,* extending to it simply a different "specific" rank. Later, on the basis of divergences between the infantile dentitions of Taungs and Kromdraai, he separated the large-brained *Paranthropus robustus* "generically and specifically" from both *Australopithecus* (now *Plesianthropus*) *transvaalensis* and *Australopithecus africanus.* That procedure has directed attention to dental differences which may serve ultimately to distinguish the several known members of the group; but modern concepts and the evidence Broom himself has been accumulating since then give lessening support to the idea of "generic" status for each of these closely-related proto-human types. It seems probable from the human nature of the Makapansgat deposit and the human features of this occiput that the whole "subfamily" of Australopithecinae have nothing more than "generic" rank within the "sub-family" Hominidae.

In conclusion I seize this opportunity of expressing my indebtedness to James Kitching who found and developed the specimen; to the many students who worked at the dumps, particularly Messrs. P. V. Tobias, S. Brenner and O. Mollet;

to various members of the departmental staff, Messrs. E. W. Williams, J. G. Bryden and the late Owen Jones, and especially Mr. D. S. Dry for the photographs and Mr. A. R. Hughes for his skilled work on the baboon fossils, the casts and line-drawings necessitated by the investigation; and finally to the artistic ability of Mr. J. F. Heim who prepared most of the pictures that illustrate this note.

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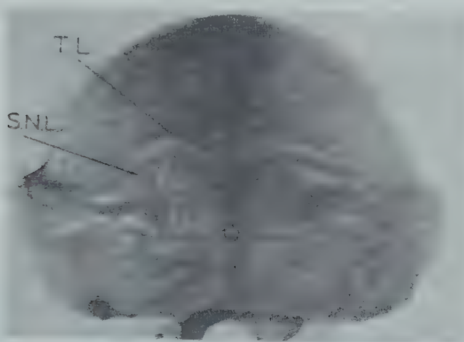
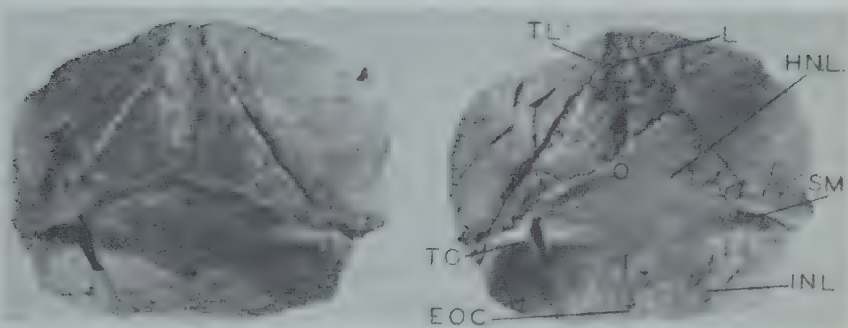
PLATE 1

EXPLANATION OF FIGURES

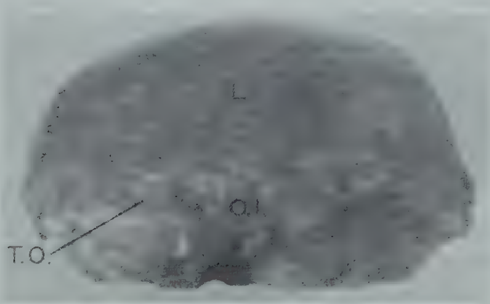
Occiputs of chimpanzee (above), *Australopithecus prometheus* (actual specimen, left central, cast with sutural pattern outlined in Indian ink, right central) and Pithecanthropus I cast (below). Note relative positions of lambda (L) inion (I) and opisthocranion (O) in the 3 specimens. Other abbreviations: superior temporal line (T.L.), torus occipitalis (T.O.), sutura mendosa (S.M.), highest nuchal line (H.N.L.), superior nuchal line (S.N.L.), inferior nuchal line (I.N.L.), and external occipital crest (E.O.C.).



CHIMPANZEE
actual



actual AUSTRALOPITHECUS cast



PITHECANTHROPUS
cast

FUTURE WORK IN SOUTH AFRICA.— When we look ahead . . . we are practically just on the threshold of research with respect to the physical anthropology of our white population. There is first of all the question of establishing a correct average of the different body proportions. We must ascertain how far these proportions differ in the various geographical regions of South Africa. Then there is the question of isolated communities. In the Cape Province we have at least 3 such communities: a Namaqualand community, one occupying a small mountainous area near Prince Albert, and the Knysna Bush community. In the Transvaal we have the people occupying the malaria-stricken region.— C. S. Grobbelaar. Anthropometry and its role in South Africa. S. Afr. J. Sci., vol. 44, March, 1948, pp. 50–60.

TEETH OF WHITES AND NEGROES.— It can be ascertained that the evolutionary processes tending on one hand towards [Klaatsch's] positive profile of chin and on the other hand towards [Gregory and Hellman's] progressive plus pattern of molars are in black races more recent than in white races. It may seem possible that at the initial stage of development these 2 dynamic processes cannot go together without some mutual interference. But it may be also possible that as soon as those orthogenetic processes are advanced beyond a certain stage, their further joint development may proceed without interference. This supposition would explain why in white races there is an absolute independence of the studied attributes, while in black races there seems to be a slight negative association.

There may be some other explanations possible. For instance it is conceivable that the negative trend observed in the African series [from the Uganda] may be due to the racial types which this series represents. Unfortunately, however, this question cannot be explained, at present, since this material has not been racially defined. — Wanda Steślicka. Wzór dryopitekoidalny na molarach żuchwy człowieka (The Dryopithecus-pattern in human lower molars). Annales Univ. Mariae Curie-Sklodowska, Lublin, vol. 3, no. 6, sec. C, 1948, pp. 195–222 (In Polish with English summary).

THE HUMERUS OF PARANTHROPUS ROBUSTUS

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TWENTY-FIVE FIGURES

Among the limb fragments found in 1938 at Kromdraai, South Africa, associated with the type skull of the fossil Australopithecine primate, *Paranthropus robustus,* is the distal end of a right humerus, extremely well preserved except that a small flake is absent from the anterior aspect of the capitulum. This specimen has been described by Broom (part I of Broom and Schepers, '46) and has been further discussed by Le Gros Clark ('47a, '47b). Both of these writers have stated that this humeral fragment is basically human in morphology rather than anthropoid-ape, and Broom has used it as a main prop in his argument that the Australopithecine forelimb was essentially similar to that of man and was not used for support of the body as in simian primates. These claims, however, are not supported by the requisite comparisons, metric and otherwise, with other primates. Nor have adequate illustrations of the bone been published (strangely, no photographs have been made available). For this reason, particularly in view of the far-reaching and important claims that have been made respecting the significance of this fragment, its careful re-study has been indicated.

Through the kindness of Dr. William K. Gregory of the American Museum of Natural History, I have been able to study a plaster cast of the Paranthropus humerus sent to him by Doctor Broom. This cast is apparently a good replica of the original specimen, for the only measurements given by Broom for the original, namely, "greatest width across the condyles" and "greatest width across the articular surfaces," agree to the millimeter with those taken from the cast.

When I first examined the cast, it was obvious that, although Broom and Le Gros Clark were correct in affirming the general human appearance of the fossil humerus, it also quite closely resembles the humeri of the anthropoid apes, particularly that of the chimpanzee, and that it is basically unlike the humeri of catarrhine monkeys. It soon became apparent, moreover, that even apart from size, its closer morphological affinities are with man and chimpanzee — rather than with gorilla, orang-utan or Hylobatidae — and that a choice bebetween these 2 could possibly be attained only after study of adequate series of specimens. Consequently, I have compared the Paranthropus cast, both metrically and otherwise, with statistically adequate series of human and chimpanzee humeri and have included smaller series of other catarrhine humeri for purposes of general comparison. It must be realized, however, that all comparisons involving the smaller series are highly tentative.

MATERIAL AND METHODS

The material used for detailed metric comparison with the Paranthropus humerus comprises 37 men (11 Whites, U. S.: 6 ♂, 5 ♀; 12 Negroes, U. S.: 6 ♂, 6 ♀; 5 Kaffirs, all ♂; 9 Australians: 5 ♂, 4 ♀), 28 chimpanzees (13 ♂, 15 ♀), 4 gorillas (all ♀), 3 orang-utans (all ♀), 4 Hylobatidae (1 ♂ and 1 ♀ *Hylobates lar*, 1 ♂ and 1 ♀ *Symphalangus syndactylus*), 2 baboons (1 ♂ *Papio sphinx*, 1 ♂ *P. porcarius*), and 1 rhesus monkey (*Macaca mulatta*, ♀).[1] All of these are adult animals. In each specimen, the right humerus was studied, except in 2 Australians and 1 chimpanzee where the right bone was missing or badly damaged. All of the non-human material, save only 3 chimpanzees and the single rhesus monkey, was from wild-shot specimens; none exhibited any pathological condition.[2] A number of other specimens were also examined but

[1] Unfortunately, no specimens of Bushmen were available for study.

[2] In all absolute measurements, the 3 captive chimpanzees fall within the ranges of variation of the 25 wild-shot specimens. In 2 of the 19 indices used, 1 of the captive animals falls slightly outside the wild-shot range, and in another index 2 of the captive animals lie just outside the wild-shot range. Considering this close agreement, the inclusion of the captive animals appears completely justifiable.

were not measured. Of the measured material, the Division of Physical Anthropology, U. S. National Museum, supplied 35 of the human specimens; the Division of Mammals, U. S. National Museum, furnished 12 chimpanzees, 3 gorillas, 2 orang-utans, 3 Hylobatidae, and 1 baboon; and the Department of Anatomy, Western Reserve University, supplied 13 chimpanzees. I wish to thank Dr. T. D. Stewart, Dr. Remington Kellogg and Prof. Normand L. Hoerr for their generosity in permitting study of these specimens, and Dr. William K. Gregory for the loan of the cast of the Paranthropus humerus. The remainder of the material came from the collections in the Department of Anatomy, The Johns Hopkins University.

Nine measurements and 1 angle were taken on each specimen:

Trochlea width (TW) = direct distance between the mid-point on the medial border of the trochlea and a corresponding point on its lateral border, taken in the transverse axis of the trochlea.

Trochlea depth (TD) =projected distance between the most anterior and the most posterior points on the medial border of the trochlea, taken at a right angle to the preceding measurement.

Capitulum width (CW) = direct distance between the most lateral point on the capitulum and the groove separating capitulum and trochlea, taken in the transverse axis of the capitulum.

Width of articular surface (AW) =direct distance between the mid-point on the medial border of the trochlea and the mid-point on the lateral border of the capitulum.

Bi-epicondylar width (BW) =greatest distance between the most projecting points on the sides of the epicondyles.

Width of medial epicondyle (MW) = direct distance between the most ulnar point on the medial epicondyle and the medial border of the trochlea (or its proximally continued projection), taken at a right angle to the long axis of the lower end of the shaft of the humerus.

Width of fossa olecrani (FW) = greatest width of the olecranon fossa above the distal humeral articular surface, taken at a right angle to the long axis of the lower end of the shaft of the humerus.

Greatest width of lower humerus shaft (SW) = greatest width of humeral shaft just above the fossa olecrani, taken at a right angle to the long axis of the lower end of the shaft.

Greatest depth (or thickness) of lower humerus shaft (SD) = greatest antero-posterior thickness of humeral shaft just above the fossa olecrani.

Angle of articular inclination = angle between the long axis of the lower end of the humeral shaft and a line tangent to the lower end of the distal humeral articular surface.

A number of these measurements are similar to, but in most instances not identical with, measurements given by R. Martin ('28, vol. 2, pp. 1010–1014).

An attempt was made to measure the size of the lateral humeral epicondyle, but since I was unable to obtain any reasonable degree of precision because of the irregular and frequently ill-defined form and contour of this structure, this measurement was discarded.

OBSERVATIONS

Absolute dimensions. In all of the 9 absolute measurements taken, the Paranthropus humerus agrees with both my human and my chimpanzee series of humeri (table 1). It is smaller than the average man and the average chimpanzee, however, in all of these characters (an exception is capitulum width, CW, in which it exactly equals the mean for man).

A striking result of this study is the essential agreement in absolute size and in variability of the lower end of the humerus in man and chimpanzee; statistically significant differences between their means occur in 5 measurements (CW, AW, BW, MW, FW) but are emphatic in only 3 of these (CW, MW, FW). In 2 of the latter (MW, FW), man is the larger. In 3 of these significant differences (CW, AW, BW), the value for *Paranthropus* is closer to the human mean; in the other 2 instances (MW, FW), it is closer to the mean of the chimpanzee. The human and chimpanzee standard deviations are statistically similar for all measurements (table 2).

The similarity of *Paranthropus* to both man and chimpanzee is demonstrated by the fact that the fossil falls outside the observed ranges of variation in only 2 measurements (SD,

TABLE 1

ans and ranges of variation of absolute measurements and indices of the lower end of the humerus in Paranthropus, man, chimpanzee, gorilla, orang-utan, Hylobatidae (Hylobates, Symphalangus), baboon (Papio), and rhesus monkey (Macaca mulatta)

MBER OF PECIMENS	PARANTHROPUS 1	MAN 37	CHIMPANZEE 28	GORILLA 4	ORANG-UTAN 3	HYLOBATIDAE 4	BABOON 2	RHESUS MONKEY 1
chlea w. (TW)	20.0	22.8 (19–28)	22.0 (19–26)	30.0 (26–36)	21.7 (20–23)	10.3 (9–12)	15.0 (14,16)	10.0
chlea d. (TD)	23.0	25.7 (21–32)	25.6 (22–29)	29.5 (25–34)	24.3 (23–25)	12.3 (11–13)	20.0 (20,20)	15.0
itulum w. (CW)	16.0	16.0 (13–19)	17.3 (14–19)	18.3 (17–19)	15.3 (15–16)	8.5 (7–10)	14.0 (13,15)	11.0
. surf. w. (AW)	40.0	43.3 (36–51)	44.8 (40–50)	54.3 (49–63)	41.3 (40–42)	22.0 (20–24)	30.5 (28,33)	23.0
pic. w. BW)	54.0	58.6 (48–67)	61.1 (51–70)	78.0 (70–91)	58.3 (54–62)	29.3 (27–32)	41.0 (39,43)	29.0
l. epic. w. (MW)	19.0	24.1 (18–31)	19.9 (14–25)	26.5 (23–31)	16.0 (12–19)	7.8 (7–9)	14.5 (12,17)	10.0
fossa w. (FW)	21.0	27.0 (20–32)	25.4 (22–30)	28.5 (24–36)	24.3 (22–26)	12.8 (10–16)	14.5 (14,15)	12.0
ft w. SW)	31.0	37.6 (29–46)	39.3 (31–46)	41.5 (37–53)	40.7 (36–46)	18.0 (16–19)	29.0 (26,32)	17.0
ft d. SD)	13.0	16.6 (13–20)	16.9 (14–20)	19.3 (19–20)	13.3 (12–14)	8.3 (7–9)	13.5 (12,15)	8.0
lin. Angle	96.0°	95.9° (90–104)	94.8° (87–106)	92.5° (86–98)	90.7° (87–93)	99.5° (97–104)	102.0° (100–104)	99.0°
× 100 / SW	129.0	116.2 (91.0–150.0)	114.6 (100.0–129.0)	131.8 (118.8–140.4)	102.7 (91.4–116.6)	125.0 (115.2–133.3)	105.4 (103.1, 107.7)	135.3
× 100 / AW	50.0	52.6 (46.4–58.4)	49.2 (43.2–54.4)	55.2 (53.1–57.2)	52.4 (50.0–54.8)	46.7 (41.7–50.0)	49.3 (48.5, 50.0)	43.5
× 100 / BW	37.0	38.9 (33.3–44.7)	36.1 (31.7–39.2)	38.4 (37.1–39.6)	37.2 (35.5–39.0)	35.5 (32.1–37.5)	36.6 (35.9, 37.2)	34.5
× 100 / TW	115.0	113.7 (95.9–131.6)	117.2 (96.0–136.9)	98.7 (94.5–107.1)	112.9 (100.0–125.0)	120.1 (108.3–130.0)	134.0 (125.0, 142.9)	150.0
× 100 / AW	40.0	37.0 (31.7–41.5)	38.5 (35.0–41.8)	33.9 (30.2–36.8)	37.2 (35.8–40.0)	38.5 (35.0–41.7)	46.0 (45.5, 46.4)	47.9

TABLE 1 (*continued*)

NUMBER OF SPECIMENS	PARANTHROPUS 1	MAN 37	CHIMPANZEE 28	GORILLA 4	ORANG-UTAN 3	HYLOBATIDAE 4	BABOON 2	RHESU[S] MONKE[Y] 1
$\frac{CW \times 100}{BW}$	29.6	27.3 (23.2–31.5)	28.3 (25.8–31.6)	23.6 (20.9–25.7)	26.4 (24.2–29.6)	29.0 (25.9–33.3)	34.1 (33.3, 34.9)	39.0
$\frac{CW \times 100}{TW}$	80.0	70.7 (56.6–84.2)	79.2 (66.7–90.0)	61.5 (52.8–69.2)	71.1 (65.3–80.0)	83.5 (70.0–100.0)	93.4 (92.9, 93.8)	110.0
$\frac{TD \times 100}{SD}$	176.9	155.7 (127.8–176.9)	151.5 (135.3–170.7)	153.1 (131.8–170.0)	183.6 (164.2–208.3)	157.4 (144.6–177.8)	150.0 (133.3, 166.7)	187.5
$\frac{BW \times 100}{AW}$	135.0	135.3 (120.0–150.0)	136.1 (126.6–146.5)	143.6 (136.3–150.9)	141.0 (135.0–147.5)	133.3 (125.0–140.0)	134.8 (130.3, 139.2)	126.0
$\frac{BW \times 100}{SW}$	174.2	156.8 (132.6–180.0)	156.0 (138.9–177.8)	188.6 (171.3–202.5)	144.4 (134.6–163.5)	163.0 (142.0–175.0)	142.2 (134.4, 150.0)	170.7
$\frac{MW \times 100}{BW}$	35.2	41.0 (32.3–48.5)	32.6 (24.2–37.1)	33.9 (32.4–36.3)	27.2 (22.2–30.7)	26.6 (21.8–30.0)	35.2 (30.8, 39.5)	34.5
$\frac{MW \times 100}{AW}$	47.5	55.7 (40.0–65.4)	44.5 (31.8–53.5)	48.8 (44.3–54.8)	38.6 (30.0–45.3)	35.4 (29.1–40.0)	47.2 (42.9, 51.5)	43.5
$\frac{FW \times 100}{TW}$	105.0	119.1 (83.3–152.6)	115.7 (92.0–133.3)	92.7 (84.6–100.0)	112.9 (100.0–130.0)	124.2 (100.0–133.3)	97.3 (87.5, 107.1)	120.0
$\frac{FW \times 100}{AW}$	52.5	62.5 (44.5–70.9)	56.7 (48.0–64.5)	52.5 (48.1–57.2)	59.0 (52.4–65.0)	57.7 (50.0–66.7)	48.0 (42.4, 53.6)	52.
$\frac{FW \times 100}{BW}$	38.9	46.1 (37.1–53.7)	41.7 (35.4–48.4)	36.3 (34.9–39.6)	42.2 (35.5–48.1)	43.4 (37.1–50.0)	35.6 (32.6, 38.5)	41.
$\frac{FW \times 100}{SW}$	67.7	72.4 (60.0–86.3)	65.4 (54.8–78.5)	68.8 (64.9–74.5)	60.8 (47.8–69.5)	71.1 (52.7–84.3)	50.8 (43.8, 57.8)	70.
$\frac{SD \times 100}{SW}$	41.9	44.5 (37.2–56.7)	43.2 (37.0–51.4)	47.4 (37.8–51.4)	33.1 (30.0–38.9)	45.8 (42.1–50.0)	46.6 (46.2, 46.9)	47.
$\frac{CW \times 100}{MW}$	84.2	67.0 (54.2–94.4)	87.5 (73.9–121.4)	69.8 (61.3–78.3)	100.1 (78.9–133.3)	109.9 (100.0–128.6)	98.3 (88.2, 110.3)	110.
$\frac{CW \times 100}{FW}$	76.2	59.8 (50.0–85.0)	68.3 (58.6–81.8)	65.3 (52.8–75.0)	63.2 (60.0–68.2)	67.5 (56.3–76.9)	90.0 (86.7, 93.3)	91.

TABLE 2

Means (with standard errors) and standard deviations (with standard errors) of absolute measurements and indices of the lower end of the humerus in man and chimpanzee. The values obtained for Paranthropus are included for comparison. Standard errors are used throughout

		MAN (37)	CHIMPANZEE (28)	PARANTHROPUS (1)
Trochlea w.	M	22.8 ± 0.36	22.0 ± 0.34	20.0
(TW)	σ	2.24 ± 0.26	1.84 ± 0.24	
Trochlea d.	M	25.7 ± 0.38	25.6 ± 0.36	23.0
(TD)	σ	2.34 ± 0.27	1.94 ± 0.25	
Capitulum w.	M	16.0 ± 0.24	17.3 ± 0.23	16.0
(CW)	σ	1.47 ± 0.17	1.23 ± 0.16	
Art. surf. w.	M	43.3 ± 0.56	44.8 ± 0.50	40.0
(AW)	σ	3.43 ± 0.39	2.66 ± 0.35	
Bi-epic. w.	M	58.6 ± 0.76	61.1 ± 0.87	54.0
(BW)	σ	4.64 ± 0.53	4.65 ± 0.62	
Med. epic. w.	M	24.1 ± 0.47	19.9 ± 0.44	19.0
(MW)	σ	2.88 ± 0.33	2.35 ± 0.31	
Ol. fossa w.	M	27.0 ± 0.40	25.4 ± 0.42	21.0
(FW)	σ	2.45 ± 0.28	2.27 ± 0.30	
Shaft w.	M	37.6 ± 0.70	39.3 ± 0.67	31.0
(SW)	σ	4.31 ± 0.50	3.59 ± 0.47	
Shaft d.	M	16.6 ± 0.27	16.9 ± 0.25	13.0
(SD)	σ	1.68 ± 0.19	1.33 ± 0.17	
Inclin. Angle	M	95.9° ±0.55	94.8° ±0.73	96.0°
	σ	3.38 ± 0.39	3.88 ± 0.51	
$\frac{AW \times 100}{SW}$	M	116.2 ± 1.83	114.6 ± 1.37	129.0
	σ	11.16 ± 1.29	7.28 ± 0.97	
$\frac{TW \times 100}{AW}$	M	52.6 ± 0.50	49.2 ± 0.46	50.0
	σ	3.05 ± 0.35	2.45 ± 0.32	
$\frac{TW \times 100}{BW}$	M	38.9 ± 0.48	36.1 ± 0.42	37.0
	σ	2.96 ± 0.34	2.24 ± 0.29	
$\frac{TD \times 100}{TW}$	M	113.7 ± 1.45	117.2 ± 2.01	115.0
	σ	8.82 ± 1.02	10.67 ± 1.42	

TABLE 2 *(continued)*

		MAN (37)	CHIMPANZEE (28)	PARANTHROPUS (1)
$\frac{CW \times 100}{AW}$	M	37.0 ± 0.39	38.5 ± 0.29	40.0
	σ	2.42 ± 0.28	1.55 ± 0.20	
$\frac{CW \times 100}{BW}$	M	27.3 ± 0.27	28.3 ± 0.28	29.6
	σ	1.70 ± 0.19	1.49 ± 0.19	
$\frac{CW \times 100}{TW}$	M	70.7 ± 1.02	79.2 ± 1.05	80.0
	σ	6.26 ± 0.72	5.57 ± 0.74	
$\frac{TD \times 100}{SD}$	M	155.7 ± 1.93	151.5 ± 1.79	176.9
	σ	11.76 ± 1.36	9.48 ± 1.26	
$\frac{BW \times 100}{AW}$	M	135.3 ± 1.18	136.1 ± 1.03	135.0
	σ	7.22 ± 0.83	5.45 ± 0.72	
$\frac{BW \times 100}{SW}$	M	156.8 ± 1.86	156.0 ± 1.90	174.2
	σ	11.34 ± 1.31	10.09 ± 1.34	
$\frac{MW \times 100}{BW}$	M	41.0 ± 0.59	32.6 ± 0.54	35.2
	σ	3.62 ± 0.42	2.88 ± 0.38	
$\frac{MW \times 100}{AW}$	M	55.7 ± 0.93	44.5 ± 0.86	47.5
	σ	5.66 ± 0.65	4.59 ± 0.61	
$\frac{FW \times 100}{TW}$	M	119.1 ± 2.12	115.7 ± 2.15	105.0
	σ	12.94 ± 1.50	11.38 ± 1.52	
$\frac{FW \times 100}{AW}$	M	62.5 ± 0.66	56.7 ± 0.82	52.5
	σ	4.03 ± 0.46	4.37 ± 0.58	
$\frac{FW \times 100}{BW}$	M	46.1 ± 0.49	41.7 ± 0.65	38.9
	σ	2.98 ± 0.34	3.48 ± 0.46	
$\frac{FW \times 100}{SW}$	M	72.4 ± 1.13	65.4 ± 1.27	67.7
	σ	6.89 ± 0.80	6.73 ± 1.27	
$\frac{SD \times 100}{SW}$	M	44.5 ± 0.69	43.2 ± 0.50	41.9
	σ	4.24 ± 0.49	2.67 ± 0.35	
$\frac{CW \times 100}{MW}$	M	67.0 ± 1.40	87.5 ± 1.88	84.2
	σ	8.54 ± 0.99	9.95 ± 1.33	
$\frac{CW \times 100}{FW}$	M	59.8 ± 0.95	68.3 ± 1.12	76.2
	σ	5.80 ± 0.67	5.96 ± 0.79	

FW). In both of these instances, it lies 1 mm below the range of the chimpanzee but is just within that of man. Respecting the former measurement (SD), this can have no meaning inasmuch as neither the means nor the standard deviations of man and chimpanzee differ significantly. Regarding the latter measurement (FW), it would appear at first glance as if *Paranthropus* more nearly resembles man; for whereas there is a significant difference between the human and chimpanzee means no difference exists between their standard deviations. Yet *Paranthropus* is actually closer to the chimpanzee in fossa width, for the mean value of the latter is clearly smaller than that of man.

TABLE 3

Values of the deviation index (d/σ) for absolute measurements of Paranthropus, relative to man and chimpanzee. d represents the deviation of Paranthropus from the corresponding human or chimpanzee mean, and σ represents the respective standard deviation of man or chimpanzee

	MAN	CHIMPANZEE		MAN	CHIMPANZEE
TW	—1.25	—1.08	MW	—1.77	—0.38
TD	—1.15	—1.34	FW	—2.44	—1.93
CW	0.00	—1.05	SW	—1.53	—2.31
AW	—0.96	—1.80	SD	—2.14	—2.93
BW	—0.99	—1.52			
			Ave.	1.35	1.59

The foregoing statements are confirmed by the "deviation index," d/σ, d representing the deviation of *Paranthropus* from the human or chimpanzee mean, and σ representing the respective standard deviation of man or ape (table 3). Using this criterion, it will be noted that as a whole *Paranthropus* more closely approaches the average man than it approaches the average chimpanzee in size; for in only 3 absolute dimensions is it closer to the latter animal. Yet the average difference is so slight that it cannot be regarded as significant.

The angle of articular inclination yields a similarly negative result. The means of man and chimpanzee are not significantly different, and the Paranthropus angle falls within the observed range of variation of each animal.

Although the measured series of other catarrhines are composed of very few specimens, it is obvious that in absolute size the fossil humerus is very much smaller than that of the gorilla, agrees quite well in most dimensions with that of the orang-utan, is larger than that of the baboon (the shaft being excepted), and is strikingly larger than the humeri of the macaque, gibbon and siamang (table 1).

Proportions. Seventeen of the calculated indices or ratios were selected with a view towards expressing the form of the bone and to give some idea of relationships of possible physiological significance. The 2 remaining ratios have utilized those 3 measurements in which man and chimpanzee clearly are significantly different (CW, MW, FW), with the hope of finding some index which might help in establishing the closer affinity of the fossil specimen (table 1).

As in the absolute measurements, man and chimpanzee show, in general, no great dissimilarity, although there are a number of statistically significant differences; moreover, the standard deviations are statistically identical for all except 3 ratios (AW $\times$ 100/SW, CW $\times$ 100/AW, SD $\times$ 100/SW) (see table 2). Again, furthermore, *Paranthropus* regularly falls within the observed ranges of variation of both animals. In only 1 index (TD $\times$ 100/SD) does the fossil value lie outside an observed range, falling well above the upper limit of the chimpanzee and exactly equalling the uppermost value for man. But inasmuch as neither the human and chimpanzee means nor standard deviations differ significantly, this particular deviation has clearly no real meaning and *Paranthropus* can be viewed as within the variation limits of both animals.

In general, however, *Paranthropus* bears a greater resemblance to the average chimpanzee than to the average man; for in 14 of the 19 indices its value is closer to the mean of the anthropoid ape (see tables 1 and 2). This is convincingly demonstrated when one considers the 12 indices in which there are significant differences between the means of chimpanzee and man (TW $\times$ 100/AW, TW $\times$ 100/BW, CW $\times$

100/AW, CW × 100/BW, CW × 100/TW, MW × 100/BW, MW × 100/AW, FW × 100/AW, FW × 100/BW, FW × 100/SW, CW × 100/MW, CW × 100/FW). In each of these, the fossil is definitely nearer to the chimpanzee mean than to the human mean, and in 8 indices (CW × 100/TW, MW × 100/BW, MW × 100/AW, FW × 100/AW, FW × 100/BW, FW × 100/SW, CW × 100/MW, CW × 100/FW) this closer approach is quite marked, particularly in 3 of them (CW × 100/TW, CW × 100/MW, CW × 100/FW).

The position of *Paranthropus* with respect to 2 of these 3 indices is of interest and perhaps significance. Both of these concern the relative width of the capitulum (CW). In capitulum width compared with width of medial epicondyle (CW × 100/MW), the fossil value lies in the lower half of the chimpanzee range and in the upper half of the human range, but it is very much closer to the mean of the chimpanzee than to that of man. For, of the 37 men, only 2 have values equal to or above that of *Paranthropus,* whereas of the 28 chimpanzees, 12 have values equal to or below that of the fossil. Thus *Paranthropus* is an outlier with regard to man, whereas approximately typical respecting the chimpanzee.

Similar conditions prevail when capitulum width is compared with width of olecranon fossa (CW × 100/FW). *Paranthropus* is located within the upper halves of the ranges of both man and chimpanzee, close to the extreme limit of each, but is very much nearer to the mean of the latter animal. Of the 37 men, only 1 has a value equal to or above that of the fossil, whereas of the 28 chimpanzees 4 possess values equal to or above it. Furthermore, of the 36 men below *Paranthropus,* none is closer to the fossil value than 9.5 index units and only 3 come as near as 10.8 units; in the chimpanzee, however, of the 24 below *Paranthropus,* 11 lie as near as 9.5 units and 13 within 10.8 units of the fossil specimen. Hence *Paranthropus* again is distinctly an outlier relative to man, but not so definitely relative to the chimpanzee.

All of the above is amply confirmed by the deviation indices for ratios (table 4). Here, moreover, the greater resemblance

of *Paranthropus* to the chimpanzee is quite striking, for its average index is 1.33 when compared with man, but only 0.85 when compared with the chimpanzee.

When all indices are considered, it can be noted that *Paranthropus* definitely exhibits a greater proportional resemblance to the chimpanzee respecting capitulum width (CW), medial epicondyle width (MW) and olecranon fossa width (FW), and less obvious resemblance with regard to trochlea width (TW), articular surface width (AW) and bi-epicondylar width (BW). On the other hand, it is suggested that in

TABLE 4

Values of the deviation index (d/σ) for ratios (indices) of Paranthropus, relative to man and chimpanzee. d represents the deviation of Paranthropus from the corresponding human or chimpanzee mean, and σ represents the respective standard deviation of man or chimpanzee

	MAN	CHIMPANZEE		MAN	CHIMPANZEE
AW × 100/SW	+ 1.14	+ 1.97	MW × 100/BW	— 1.60	+ 0.90
TW × 100/AW	— 0.85	+ 0.32	MW × 100/AW	— 1.44	+ 0.65
TW × 100/BW	— 0.64	+ 0.40	FW × 100/TW	— 1.08	— 0.94
TD × 100/TW	+ 0.14	— 0.20	FW × 100/AW	— 2.48	— 0.96
CW × 100/AW	+ 1.23	+ 0.96	FW × 100/BW	— 2.41	— 0.80
CW × 100/BW	+ 1.35	+ 0.87	FW × 100/SW	— 0.68	+ 0.34
CW × 100/TW	+ 1.48	+ 0.14	SD × 100/SW	— 0.61	— 0.48
TD × 100/SD	+ 1.80	+ 2.67	CW × 100/MW	+ 2.01	— 0.33
BW × 100/AW	— 0.04	— 0.20	CW × 100/FW	+ 2.82	+ 1.32
BW × 100/SW	+ 1.53	+ 1.80	Ave.	1.33	0.85

relative trochlea depth (TD) *Paranthropus* is more like man. In the 2 shaft measurements the fossil exhibits no preference.

Paranthropus, however, is in no sense truly intermediate between chimpanzee and man. Its value falls between the anthropoid and human means in but 7 of the 19 indices, and in only 6 of the 12 instances in which there is a demonstrably valid difference between this ape and man.

In so far as their small series permit conclusions, it may be noted that the other primates studied — gorilla, orang-utan, Hylobatidae, baboon, macaque — in general show less re-

semblance in form to *Paranthropus* than does the chimpanzee, but, except for the 2 monkeys and perhaps the orang-utan, they are probably no further removed than is man (table 1). The various degrees of departure seem to differ, however, in detail. On the basis of all the calculated means of the indices, the chimpanzee differs clearly from *Paranthropus* only in having a relatively deeper shaft (with suggestions of a relatively wider olecranon fossa, slightly wider shaft, and slightly narrower medial epicondyle). The human differences from the fossil involve medial epicondyle (relatively much wider), fossa (relatively much wider), shaft (relatively deeper) and capitulum (relatively much narrower)—with some suggestion of a relatively smaller bi-epicondylar width. The gorilla differs from *Paranthropus* in regard to trochlea (relatively much broader and slightly shallower), capitulum (relatively much narrower), bi-epicondylar width (relatively greater), and shaft (relatively narrower and deeper). Thus the lower end of the gorilla humerus, if the present very small series is at all representative of this animal, is farther removed from that of the chimpanzee than is that of *Paranthropus*. The Hylobatidae exhibit departures from *Paranthropus* respecting trochlea (relatively narrower), medial epicondyle (relatively much narrower), olecranon fossa (relatively much broader), and shaft (relatively somewhat wider). The orang-utan shows differences in medial epicondyle (relatively much narrower), fossa (relatively wider) and shaft (relatively broader and shallower)—and possibly also capitulum (relatively wider). The baboon deviates in capitulum (relatively much broader), fossa (relatively somewhat narrower) and shaft (relatively wider and deeper)—with differences in bi-epicondylar and medial epicondylar widths also indicated. The macaque differs from *Paranthropus* regarding trochlea (relatively narrower and deeper), capitulum (relatively very much broader), medial epicondyle (relatively narrower), and shaft (relatively narrower), and perhaps in bi-epicondylar width (relatively narrower) as well.

In the proportions of its component parts, the distal end of the Paranthropus humerus thus bears a closer resemblance to the so-called "higher" catarrhines than to the so-called "lower" catarrhines or monkeys. But it is in no manner intermediate in form between the anthropoid apes and man. Man and the several anthropoids differ among themselves, and *Paranthropus* exhibits various degrees of affinity to the individual members of this taxonomic group. The present analysis permits no definite conclusions as to the precise affinities of *Paranthropus*. But it may not be amiss to note that it suggests that its closest relative approach is to man, chimpanzee and orang respecting form of trochlea, to chimpanze and Hylobatidae in width of capitulum, to chimpanzee, gorilla and orang in total articular surface width, to chimpanzee, orang and Hylobatidae in bi-epicondylar width, to chimpanzee in width of medial epicondyle, to gorilla in width of fossa olecrani, and to man in form of shaft.

Other characters. Further examination of the humeri of catarrhines tends to bear out the results of the metric study. The humerus of *Paranthropus* shows a general strong resemblance to those of man, chimpanzee, gorilla, and gibbon, does not so closely approximate that of the average orang-utan, and is quite different from those of the baboon and macaque (see figs. 2–25).

The articular surface of *Paranthropus* is more like that of the average chimpanzee than like that of the average man, although considerable variability is evident in this structure when large series of these animals are studied.

More of the capitulum is situated on the distal end of the humerus in *Paranthropus* (fig. 19) than is customary in man, in whom there is a relatively greater extension over on to the anterior aspect of the bone (fig. 18). In this, the fossil agrees essentially with the usual condition in the chimpanzee, gorilla and gibbon (figs. 20, 21, 23). The orang-utan (fig. 22), however, more nearly resembles man, as do the baboon and macaque (figs. 24, 25), although the precise arrangement

in the 2 monkeys is somewhat at variance with the human one.

In most specimens of man, orang, gibbon, siamang, baboon, and macaque, the lateral border of the capitulum — when followed from the dorsal towards the ventral surface of the bone — tends to run sharply laterally, with very little curvature (figs. 18, 22, 23, 24, 25). Hence it is disposed to pass obliquely from its postero-medial border towards its antero-lateral border. This essentially straight, sharp course of the edge is regularly far less evident in the chimpanzee, in which the lateral capitular border is usually more curved, so that much of it runs from medial to lateral almost in the transverse axis of the lower end of the humerus (fig. 20). The usual condition in the gorilla is approximately intermediate between these 2 extremes (fig. 21). *Paranthropus* herein agrees strikingly with the customary chimpanzee arrangement and contrasts markedly with the common human one (fig. 19).

Broom has pointed out that the capitulum of *Paranthropus* is more flattened than that of man and anthropoids, so that it is "part of a much larger and irregular sphere." This is not so evident from visual inspection of the cast, but it is plainly indicated in diagraphic tracings even when the necessity for reconstruction of the anterior part of the contour is kept in mind (fig. 1). The capitulum of the fossil is clearly less curved than that of any other catarrhine primate that I have studied, and its degree of flatness is approached only in the macaque (fig. 1). Apparently, however, this is a character possessed of not inconsiderable variability.

Le Gros Clark has maintained that the most singular feature of the Paranthropus humeral fragment is the relative position of the articular surface, particularly of the trochlea. In his earlier paper ('47a) he stated: "In the human (and more so in the simian) humerus, the trochlea is set well forward in relation to the shaft and to the medial epicondyle. In *Paranthropus* the transverse central axis of the trochlea lies approximately within the line of the long axis of the lower end

of the shaft of the humerus. The significance of this unusual alignment is not clear.'' In his later paper ('47b) he stated that the capitulum is also involved in this backward displacement but that this relation is much more pronounced in the trochlea. He thought that this backward alignment ''must mean some limitation of the power of flexion (since the leverage in the flexor action of the biceps and brachialis muscles would be somewhat diminished) and a capacity for hyper-extension at the elbow joint to a degree not usually possible in recent anthropoid apes or man.'' This supposed peculiarity of *Paranthropus* is not borne out, however, by diagraphic tracings of shaft, trochlea and capitulum (the humerus having identical orientation in all specimens) taken from the fossil and from extant catarrhine primates (fig. 1). As a whole, conditions in the fossil do not differ materially from those in the other primates, particularly when the variability within a single species is taken into account (see the illustrated examples of man and chimpanzee).

The approximate center of the trochlea lies slightly behind the long axis of the lower portion of the humeral shaft in

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Fig. 1 Diagraphic projection tracings of the lower ends of the right humeri of *Paranthropus robustus* and extant catarrhine primates. Each humerus was oriented so that the mid-sagittal axis of the lower end of the shaft, drawn upon its posterior surface, was parallel to the ground plane. A second line of orientation, connecting the mid-points on the medial and lateral borders of the trochlea, was kept perpendicular to the ground plane. With the bone in this position, projection drawings were made of a sagittal section of the lower shaft, running along the above-mentioned mid-sagittal axis on the posterior surface (P.S.) and continuing along the anterior surface of the bone (A.S.); of the medial border of the trochlea (T.); of the middle of the capitulum (C.); and of the apex of the medial epicondyle (E.). The portion of the shaft used in the extant primates is comparable to the part present in *Paranthropus*. The line SS′ represents the transverse axis of the lower part of the humeral shaft, obtained by connecting the points midway between the anterior and posterior surfaces at the upper and lower ends. Pa., *Paranthropus;* Wh., White; Ne., Negro; Ch., chimpanzee; Go., gorilla Or., orang-utan; Hy., gibbon *(Hylobates lar)*. Ba., baboon *(Papio sphinx);* Rh., rhesus monkey *(Macaca mulatta)*. The dotted portion of the tracing of the *Paranthropus* capitulum represents the restored part of the contour. The gaps in the lower ends of the humeral shafts of the female Negro, 2 of the female chimpanzees and the gorilla represent the location of septal apertures. All × ½.

Paranthropus, as it does in 2 of the chimpanzees, the orang and the macaque. In the other 2 chimpanzees, the gibbon and the baboon, however, it is located somewhat further dorsally. In man, this point is usually more ventral in location. It is approximately central in the gorilla illustrated. Relative to the apex of the medial epicondyle, the trochlear center lies

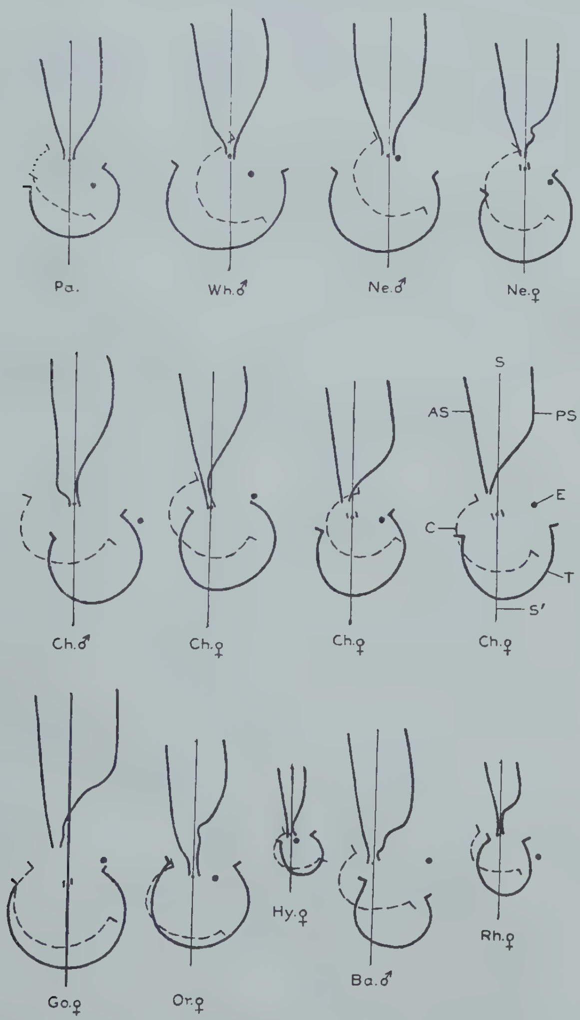

Figure 1

to the front in *Paranthropus* and all of the examples of other primates studied with the single exception of the gibbon. It is more to the front in the African anthropoids and the monkeys than it is in man, orang-utan and *Paranthropus* (and, of course, gibbon), but this is primarily only an expression of a more pronounced dorsal inclination of the entire epicondyle. Examination of the diagraphic tracings will reveal that the entire trochlea of *Paranthropus* is so oriented as to appear more twisted backwards relative to the long axis of the humeral shaft than in the 2 human males, the gorilla, the orang, the macaque, and (especially) the baboon; but there is a similar dorsal "twisting" in the human female, the chimpanzees and the gibbon. That this necessarily bespeaks a greater capacity for hyperextension of the elbow in *Paranthropus* (and in others with similar orientation), is to be doubted, however, particularly in view of the characters of the olecranon fossa, which will be discussed immediately below. The orientation of the capitulum in the existing primates and *Paranthropus* agrees in general with that of the trochlea, but is variable.

The fossa olecrani regularly is comparatively deep in the anthropoid apes and catarrhine monkeys, and relatively shallower (but not always) in man (figs. 10–17). Herein *Paranthropus* agrees essentially with man and some examples of the orang-utan. Le Gros Clark has attempted to correlate the extent and depth of the fossa and, by implication, the presence or absence of a perforation of the fossa (or "septal aperture") with the development of the olecranon process of the ulna. This is inadmissible. The moderately deep fossa of man is associated with a moderately developed olecranon, the very deep fossa of the great apes is associated with a stunted olecranon, and the very deep fossa of Old-World monkeys is associated with a highly developed olecranon. Le Gros Clark makes the inexplicable statement that the olecranon is powerfully developed in the African anthropoids, whereas it is well-known that it is poorly developed in all of the anthropoids in contrast with its moderate development

in man and its high development in monkeys (see Fischer, '06; C. P. Martin, '34). Thus, if, as Le Gros Clark has indicated, the "beak" of the olecranon process on the Paranthropus ulna is less developed than it usually is in man, this is an anthropoid rather than a hominid character. Nor is there any direct correlation between the septal aperture and the length of the olecranon process. Schultz ('37, '40, '41, '44), studying adult skeletons, found apertures in 5% of male and 18% of female Whites, in 12% of male and 35% of female Negroes, in 35% of male and 64% of female gorillas, in 27% of male and 37% of female chimpanzees, in 85% of male and 84% of female orangs, in 26% of male and 25% of female gibbons, and in 10% of male and 5% of female macaques. The absence of a septal aperture in *Paranthropus* is therefore not diagnostic. The differences that exist, whether sexual or specific, are likely related to degree of elbow extension rather than to olecranon size.

Paranthropus exhibits a distinct and relatively deep coronoid fossa, as Le Gros Clark has noted. The relative size of this depression varies considerably in living catarrhines but it is commonly shallow in monkeys and deep in the great apes and man (figs. 2–9). The radial fossa (figs. 2–9), on the other hand, is scarcely indicated in the fossil (see also Le Gros Clark), as in most chimpanzees, orangs, gibbons, and monkeys. This fossa is not infrequently better developed in man and gorilla but its size is quite variable.

The medial epicondyle of *Paranthropus* is more pointed and slender than it usually is in man (see also Broom and Le Gros Clark). In this respect it also differs from the medial epicondyle of the chimpanzee and contrasts markedly with the rather blunt epicondyles of many orang-utans and the monkeys. One finds its rather close counterpart, however, among the gorillas and the gibbons (cf. figs. 2–25).

The lateral epicondyle of *Paranthropus* is comparatively large, and I have not seen anything quite like it in man, in whom this structure is normally but poorly developed. In contrast with Broom, I do not find it to be essentially more

human than anthropoid in configuration. Although this epicondyle is regularly large and prominent in the anthropoid apes, particularly the African forms, its precise morphology differs from that of the fossil. Yet, in its relatively high development *Paranthropus* more nearly resembles the anthropoid apes than it does man and monkeys; and its form is at least approached in some specimens of the African great apes (cf. figs. 2–25).

Le Gros Clark has noted that in the fossil "the lateral supracondylar ridge is moderately defined as in man" and that "the pronator ridge on the medial border of the lower end of the shaft is weakly developed" ('47b). In his earlier paper he stated that "the humerus and ulna fragments of *Paranthropus* lack the powerful muscular ridges found in the brachiating apes, and appear to be quite closely similar to those of *Homo sapiens*" ('47a). This implication of a peculiarly human affinity in this respect is not confirmed by my study of series of primate humeri. Indeed, I have found these ridges to be so variable in their development as to permit no conclusions as to either affinities or muscular development. Among 37 human humeri, the lateral supracondylar ridge was strongly defined in 18 (9 ♂, 9 ♀), moderately defined in 8 (7 ♂, 1 ♀) and feebly defined in 11 (5 ♂, 6 ♀), thus showing no sex difference; among 28 chimpanzees, strong in 15 (9 ♂, 6 ♀), moderate in 9 (3 ♂, 6 ♀) and feeble in 4 (1 ♂, 3 ♀); among 10 gorillas (6 ♂, 4 ♀), feeble in all; among 6 orang-utans, strong in 5 (2 ♂, 3 ♀) and moderate in 1 (♂); among 4 Hylobatidae, strong in 1 (♂), moderate in 2 (1 ♂, 1 ♀) and feeble in 1 (♀); strong in 2 baboons (both ♂); and strong in 1 macaque (♀). The consistent occurrence of a weak ridge in the gorilla is a negation of a necessary correlation of ridge size and muscularity. I have not made a similar detailed study of the pronator ridge, but examination of a number of primate humeri leaves me in no doubt that this is likewise variable in its definition.

CONCLUSIONS

It is apparent from this study that the fragment of the humerus attributed to *Paranthropus robustus* must be allocated to the taxonomic group composed of the anthropoid apes and man rather than to the group of the Old-World monkeys. But it is no more hominid than it is anthropoid. In both absolute dimensions and proportions it bears a particularly close resemblance to both man and the chimpanzee. Regarding its proportions, however, it is in general more like the average chimpanzee than like the average man, but this should probably not be stressed since it consistently falls within the ranges of variation of both species. The other, non-measured features further bear out this relationship to human and anthropoid-ape humeri, although the peculiarly close resemblance to man and chimpanzee is not so evident here; yet here also the fossil is perhaps more chimpanzee-like than man-like. It must be emphasized that, in any circumstance, the Paranthropus fragment is in no manner intermediate between the humeri of the anthropoid apes and that of man, so that it does not represent a so-called "transitional stage" or "missing link."

At several points, when speaking of the various limb bones of the Australopithecines, Broom has made statements to the effect that anatomists would readily affirm their essential human character. As to the humeral fragment, I do not doubt that this would be the off-hand decision of most anatomists, particularly of those who are not familiar with the morphology of other primates. But, by the same token, I maintain that if there were anatomists among the chimpanzees their first reaction to this fossil would be to acclaim its undoubted chimpanzee affinities. This is merely another way of saying that the lower end of the humerus is basically so similar in man and the anthropoid apes that it is of extremely limited value in taxonomic and phylogenetic studies. It is no real clue to the structure of the humerus as a whole, not to speak of its inability to predict the structure and usage of the entire forelimb. It is true that Kromdraai has also yielded an ulnar

fragment, a metacarpal and 2 phalanges, and Sterkfontein a capitate (see Broom and Le Gros Clark). But the ulnar remnant is apparently indecisive, the brief description of the metacarpal and phalanges strongly suggests cercopithecid affinities, and the capitate seems to be ambiguous. All of these specimens, furthermore, need more detailed and more extensive comparative study.

The humerus therefore would seem to be the chief reason for Broom's supposition that the forelimb of *Paranthropus* was "much more like that of man than that of the arboreal anthropoids" and that the Australopithecines used their arms "not for walking or climbing, but for the manipulation of tools and weapons" (p. 115). He has also categorically asserted that "the hands were certainly not at all adapted for walking on" (p. 142, and cf. also p. 143). Le Gros Clark ('47a, '47b) has avoided such sweeping claims, yet he apparently agrees by implication. And in popular articles he has not hesitated to proclaim the essentially man-like, non-anthropoid nature of the Australopithecine forelimb (Picture Post, July 5, 1947, and The Listener, April 1, 1948, vol. 39, no. 1001, pp. 531–532). The evidence presented in the present paper makes it clear that, from the Paranthropus humerus, no such conclusions are warranted. Nor, on the face of the available published evidence regarding them, do the other forelimb bones attributed to the Australopithecines support such claims.

Whatever the nature of new discoveries, it at present would be decidedly premature to come to a decision respecting the structure and usage of the Australopithecine forelimb. Solution of the problem demands extensive comparison of the limb-bone material with other primates, on a quantitative basis wherever this is possible. Until this is done, we will not be in a position even to suggest whether the animals were bipeds, or quadrupeds, or, even though the geological evidence has been said to deny the possibility, brachiators.

SUMMARY

A plaster cast of the distal humeral fragment attributed to the Australopithecine primate, *Paranthropus robustus*, has been compared in detail, metrically and otherwise, with series of 37 human and 28 chimpanzee humeri, and with smaller series of other catarrhine primates.

Its characters are such as to allocate it to the taxonomic group comprising man and the anthropoid apes rather than to the Old-World monkey group. But it is no more hominid than anthropoid.

In absolute dimensions and in its proportions it shows a particularly close resemblance to both man and chimpanzee. In its proportions it is on the whole closer to the average chimpanzee than to the average man. This should probably not be stressed, however, for man and chimpanzee are surprisingly similar in form of the lower humerus, and the Paranthropus values consistently fall within the variation ranges of both species. Other, non-measured characters further attest to the relationship of the fossil humerus to those of man and the anthropoid apes, but the particularly close resemblance to man and chimpanzee is not so evident here. In no circumstance can the fossil fragment be regarded as intermediate or "transitional" between the humeri of the anthropoids and that of man.

The lower end of the humerus is basically so similar in man and the anthropoid apes that this region is of extremely limited value in taxonomic and phylogenetic studies. It thus gives no real clue to general humeral structure, much less to the structure and usage of the forelimb as a whole. There is no justification for the claims of Broom that the arms of the Australopithecines were not used for walking or climbing.

We still lack the evidence necessary to conclude whether the forelimb of the Australopithecines was that of a biped, or a quadruped, or a brachiator.

I am greatly indebted to Dr. Margaret Merrell of the Department of Biostatistics, School of Hygiene and Public

Health, The Johns Hopkins University, for advice regarding statistical procedure.

Mr. Chester F. Reather of the Department of Embryology, Carnegie Institution of Washington, produced the excellent photographs.

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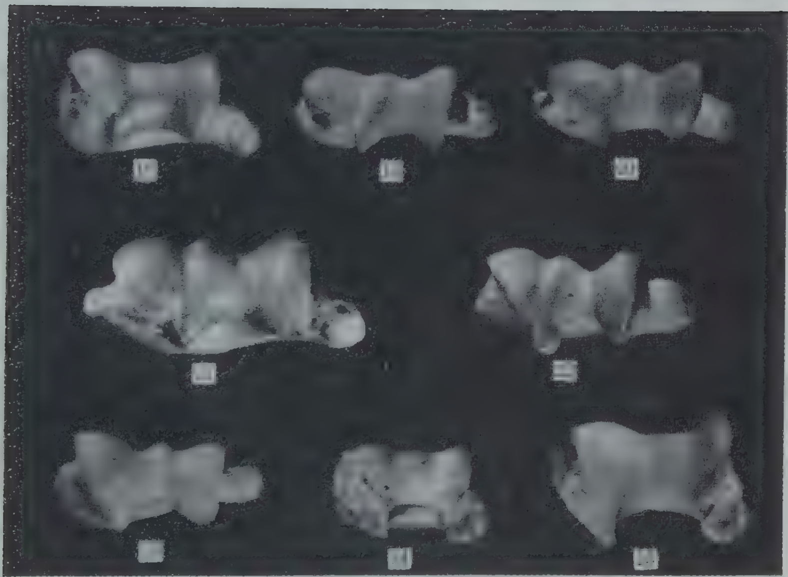
2–9 Anterior views of the lower end of the right humerus in *Paranthropus robustus* and extant catarrhine primates. 2, man (female Negro); 3, *Paranthropus;* 4, chimpanzee, female; 5, gorilla, female; 6, orang-utan, female; 7, gibbon *(Hylobates lar)*, female; 8, baboon *(Papio sphinx)*, male; 9, rhesus monkey *(Macaca mulatta)*, female. Gibbon and rhesus monkey, × 1. All others, × ½.

10–17 Posterior views of the lower end of the right humerus in *Paranthropus robustus* and extant catarrhine primates. 10, man (female Negro); 11, *Paranthropus;* 12, chimpanzee, female; 13, gorilla, female; 14, orang-utan, female 15, gibbon *(Hylobates lar)*, female; 16, baboon *(Papio sphinx)*, male; 17, rhesus monkey *(Macaca mulatta)*, female. Gibbon and rhesus monkey, × 1. All others, × ½.



18–25 The lower end of the right humerus in *Paranthropus robustus* and extant catarrhine primates, seen from below. 18, man (female Negro); 19, *Paranthropus;* 20, chimpanzee, female; 21, gorilla, female; 22, orang-utan, female; 23, gibbon *(Hylobates lar)*, female; 24, baboon *(Papio sphinx)*, male; 25, rhesus monkey *(Macaca mulatta)*, female. Gibbon and rhesus monkey, × 1. All others, × ½.

Racial Incidence of Intracranial Tumors.— There seems to be some evidence of an influence of race on the incidence of certain tumors, for example, the Japanese are said to have mammary carcinoma rather infrequently. But there is no good evidence of any racial variation in the incidence of intracranial tumors. The supposed immunity of Negroes to brain-tumors probably results from failure to diagnose. It has been recently stated that Jews are unusually susceptible to the development of hypophysial adenomas. The statistics, however, were compiled in a clinic which receives an unusually high percentage of Jews from New York City.— Percival Bailey. Intracranial tumors. 2nd ed. Charles C Thomas. Springfield, Ill., xxiv + 478 pp. and 16 pls. ($10.50).

Differential Tooth Protection from Fluoride.— It has been demonstrated . . . that there exists among the different kinds of teeth (incisors, canines, premolars, and molars) different degrees of what might be termed, characteristic susceptibility to dental decay. Hence, the molars are most frequently attacked by caries while the canines are the least often involved. To what extent are these typical or expected susceptibilities of the different teeth (determined in non-fluoride areas) influenced or affected by fluoride exposure? Are all the teeth protected to the same extent or are some teeth protected more than others?

Analysis of this, and related questions, reveals that the various morphological types of teeth in the permanent dentition are indeed affected differently by exposure to fluoride. Certain teeth, particularly those located in the anterior of the mouth, are protected most while the molars, which are placed most posterior in the mouth are protected least. — Henry Klein. Dental effects of community waters accidentally fluorinated for 19 years. II. Differences in the extent of caries reduction among the different types of permanent teeth. Public Health Rep., vol. 63, no. 18, April 30, 1948, p. 563–573.

SYMPOSIUM
ON
APPLIED PHYSICAL
ANTHROPOLOGY

The 7 papers appearing in this section were read at the 17th annual meeting of the American Association of Physical Anthropologists in Washington, Saturday afternoon, April 3, 1948. (See this Journal, n.s. *6:* 244–247.) Three other papers included in the original symposium have not been submitted for publication. These are as follows: W. M. Krogman — Medico-legal aspects of the skeleton: Related factors, as condition of interment, action of fire, reconstruction, etc.; H. L. Shapiro — Anthropology in the U. S. Army reburial program; James A. Gavan — Factors influencing anthropometric variability. Krogman's remarks are embodied in a paper being published elsewhere; Gavan's paper constitutes his master's thesis and could not be cleared in time for inclusion here.

Credit for organizing the symposium goes to Francis E. Randall. Discussion by E. A. Hooton, as scheduled, had to be omitted because of the length of the program.

MEDICO-LEGAL ASPECTS OF THE SKELETON

I. AGE, SEX, RACE AND STATURE

T. D. STEWART

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Owing to the proximity of the FBI Laboratory to the National Museum the staff of the latter's Division of Physical Anthropology (formerly Dr. Aleš Hrdlička; now Dr. Marshall T. Newman and myself) has been consulted frequently regarding the identification of skeletal remains found under suspicious circumstances. This material is sent to Washington from all over the United States and ranges from small fragments (not always known definitely to be bone) to whole skeletons. We have derived, it must be confessed, a certain satisfaction from putting our knowledge to practical test and from the expressions of appreciation from the FBI. I want to summarize, therefore, some of the things we have learned from these experiences.

Above all, law enforcement agencies want to know whether the submitted bones are human or animal. Usually it is a matter of establishing a corpus delecti. Keep in mind that all bones, especially when fragmentary, look alike to untrained observers. A laboratory technician without zoological training can determine the species of a bone, if organic matter is still present, by precipitation tests. However, this method is time-consuming, and it is quicker to have someone familiar with the morphology of bones give his opinion. If, on the other hand, the bones have been exposed to fire and the organic matter thus destroyed, identification is possible usually only on the basis of morphology. In such cases physical anthropologists are best qualified to give judgment, for only in this field are the broader aspects of skeletal remains considered.

When bones have been burned they are usually reduced to fragments by the heat. This adds to the difficulty of identification. To aid in these cases and to supply comparative material we keep a collection of burned bones from Indian cremations. As a rule, unless such fragments are convincingly distinctive we do not give positive opinions. In one recent case we refused to say that some small burned fragments were human and suggested a further search. The next lot contained unmistakably human parts. In these cases we have wished that more was known about the microscopic differentiation of human and animal bones. For instance, is human cancellous structure distinctive, even when it is not known at the start from which bone the sample comes?

As soon as the fact is established that we are dealing with human bones we try to keep in mind (for we are not always asked) the question of whether or not more than one individual is represented. The discovery of duplicate or unmatching parts in itself can be a valuable contribution. Specifically we are asked about the indications of sex, age and race. Any other information, such as stature, obviously depends upon the presence of a fairly complete skeleton. In any case, of course, the amount of information that can be given depends to a large extent upon the condition of the specimen. At the present state of our knowledge I feel that it is hazardous to estimate body-build from the skeleton.

At this point I must emphasize the danger of thought fixations. The physical anthropologist is in danger of overlooking important features if he allows anyone to tell him too much about the case in advance. For example, if the specimen is presented along with some such announcement as "Here are some bones that are believed to be those of a 40-year-old Negro woman who disappeared suddenly 3 years ago," then quite naturally the physical anthropologist may find himself thinking "Are these bones female?" instead of "What are the sex indications?" or "Do the age changes indicate 40 years?" instead of "How old was this individual?" and so on. To cite an actual case, one day Dr. Newman and an FBI Agent

came into my room and said "Here are some burned finger bones. We want to know whether you think they are human." I feel that it is not surprising, therefore, that I examined these bones as phalanges, opined that they were not human, and suggested that they be taken to the Division of Mammals for specific identification. The mammalogist somehow avoided or overcame the same fixation because the report came back that instead of being finger bones they were tail bones of a horse. This fixation on fingers caused us to overlook the vertebral structure. Fortunately, we were positive they were not human.

This is not the place to go into the methods by which the determinations of sex, age and race are made. As for sex, the margin of error in any determination varies with the parts available for examination. Given the complete skeleton of a subadult the sex identification may be little better than a guess, or little more than 50%. In adult skeletons Dr. Washburn ('48) claims he can distinguish the sex in over 90% of cases by two pelvic measurements alone. In a series of 100 American Negro skeletons examined at Washington University in St. Louis I made a correct sex identification by inspection in 94%. Having only the skull Hrdlička ('39) claimed to be able to make a correct sex identification in over 80%, and this increased to 90% when the lower jaw was present. As for myself and the Negro series already mentioned, my figure for skull with lower jaw was 77%. Once when Todd told Hrdlička of results similar to mine he was told that he should be ashamed of not being able to do better. I suspect that there is a general tendency to become over-confident of sexing ability when few opportunities for checking are available.

We all acknowledge our debt to Todd for the data he supplied on age determination. Partly as a result of his contributions it is now possible, again with reasonably complete material, to come close to the true age; that is, to within about 2 years up to age 30, and to within 5–10 years after age 30. I believe, however, we are apt to forget that the changes in the pubic symphysis and the stages of suture closure, to which

Todd set age limits, are highly variable. Any estimate should be based upon a careful weighing of each of these features with bone texture, tooth wear, vertebral arthritis, and any other age criteria. I am especially conscious of this because I work mostly with skeletal remains from archaeological sources.

Race is quite another thing again. Here in the United States almost any combination of races occurs, and especially in the lower strata of society from which medico-legal specimens are apt to come. Thus the chances of being right in a racial identification depends largely upon the observer's experience. In the case of a skull seen recently the best that I could make out regarding race was that the individual was a mixture of White and Indian. Later the FBI Agent told me the specimen was from Baton Rouge, Louisiana, and was suspected of being the remains of an old Negro who had disappeared suddenly. He asked then whether I wished to change my opinion. In spite of the temptation, I let the opinion stand and consoled myself with the thought that in Louisiana the popular designation "Negro" need not be in conformity with anthropological opinion. Since the concept of race is only skin deep it is impossible always to predict skin color from skull morphology where there has been race mixture.

In connection with race it is convenient to mention that not infrequently we have material presented for examination that turns out to be from early Indian burials. Excavations often reveal bones and the local coronors often investigate them. In such cases the opinions of physical anthropologists are the final resort. On one occasion we pronounced a skeleton as Indian and long dead. On learning it was from Colorado we were able to show that the skull type was identical with that of the Utes. Later we were informed that the skeleton had been found on a rock ledge in a canyon where one of the principal Ute chiefs had lived. An old musket had been found with the skeleton. We tried to get the skeleton for our collections but the Colorado Historical Society claimed it.

Unlike sex, age, and race, wherein the subjective factor and experience play such prominent roles, stature can be determined by anyone who can measure bones and handle correlation tables or formulae. It is a mechanical procedure. This does not mean, however, that the result is without a margin of error. Indeed we should be very unhappy about this. Our methods are still based upon a series of 50 male and 50 female French cadavers measured by Rollet in 1888. Manouvrier (1893) in calculating his tables from these data threw out over half of the series because he considered them senile. Yet Pearson (1899) used the whole 100 on the questionable basis that the series includes taller-than-average individuals among the aged. Someone should work up the extensive records of cadaver stature and bone lengths assembled at Western Reserve University and Washington University. We need not only better correlation data for Whites, but special data for other races and a better idea of the probable error involved in individual determinations.

Unless these inherent variabilities of the human body are kept in mind it seems likely that we tend to become overconfident about our ability to identify skeletons. Perhaps few realize that this attitude can be affected by the small proportion of the identifications that are verified. Although I have repeatedly asked the FBI for follow-up information and they routinely request it from the agencies they serve, it seldom gets back to me. And in my experience only 3 cases have reached court. Two of the 3 court cases involved burned fragments about which I could say little more than that they were adult humans. But my reputation as a sleuth was made, according to the magazine *True Detective,* in the first court case. There I got the sex and race right, the age to within 2 years (and should have done better), the stature to the half inch, and correctly predicted a history of left-handedness and pyorrhea.

Other cases where verification of the identifications ought to be expected have not reached me — as for example, two men found on Mt. Shasta, or a bullet-riddled skeleton buried

in quick lime near Pittsburgh. Thus there is a good chance that one's errors of interpretation likewise can escape attention and one can go along blithely making the same mistakes. It is little to ask of law enforcement agencies by way of return for such services that they go out of their way to help anthropologists check themselves.

In reporting these medico-legal experiences I have emphasized the limitations in the ability of anthropologists to identify human skeletal remains. This attitude is somewhat at variance with the implications of Dr. Krogman's statements in the guide which he prepared for the FBI in 1939. There he says (p. 1) "The study of the skeleton is an exact science, permitting of identification in terms of individual age, sex and race." And again (p. 29) "This outline will have served its purpose if it has indicated that physical anthropology, with its precise method, can bring its techniques to bear upon problems of identification." I feel that these statements are a bit on the optimistic side and create the false impression that skeletal identification is largely mechanical. No one can apply these directions properly without training. Experience in handling skeletal material, and especially documented material, is all important for avoiding mistakes. It is important to the science of physical anthropology, just as it is to the FBI, that trained workers do not make mistakes. I think we should recognize more fully that Todd with his great experience could come very close in aging and sexing dissecting room material, but that few have had so much experience, and that it is a very different thing to apply his directions to other types of material.

I have stressed the fact that caution is necessary in making identifications. We find it wise to distinguish between certainties and probabilities. It is usually certain that material is human or animal but often it is necessary to qualify an opinion of the sex and age. For further protection I recommend writing out or dictating reports. If the case comes to court it may be months after the specimens were first seen before the witness is asked to tell the jury what was said in the original

examination. In such cases, especially if the evidence is fragmentary, it is helpful and definitely more impressive to the jury, if the original notes are available for reference.

Finally, as a general summary of these remarks, let me emphasize that physical anthropology can and is making an important medico-legal contribution through careful identification of skeletal remains and that law enforcement agencies appreciate this help. From our experience, however, I would warn that everyone who makes these identifications has an obligation to his science not to become over-confident in his ability and for this reason to make mistakes. We could all go back profitably to collections of documented skeletons and become more realistic about identifying sex, race and stature.

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WASHBURN, SHERWOOD L. 1948 Sex difference in the pubic bone. Am. J. Phys. Anthrop., n.s. *6* (2): 199–207.

FACIAL RECONSTRUCTIONS.— From a skull it is quite impossible to reconstruct the character of the hair, eyes, nose, lips, ears, eyebrows, skin creases, fullness, or expression. In short, it is impossible to reconstruct the appearance of the face. Nevertheless, such fancy reconstructions are to be found in almost every book dealing with the

evolution of man. It is highly desirable that they should be dropped, for they do real harm. Their creators have endowed them with traits and expressions which follow the formula that the earlier or more primitive the type, the more brutal; the later the type, the nobler the expression. The probabilities are that the expression of early man was not less benign than our own.

As if in answer to these strictures, there appeared, after the main body of the present article was written, several papers on the reconstruction of the facial appearance of a dissecting-room [Negro] cadaver from the skull. These reports by Dr. W. M. Krogman are of considerable interest . . . [See this Journal, n.s. vol. 4, 1946, p. 501.]

On the whole, the measurements between the head and the bust were very close. This one would expect, for certainly there is some resemblance between the deceased subject and his post-mortem bust. There are differences which we need not consider here. In the Negro there are such more or less constant features, such as kinky hair, thickish lips, broad nose, and small ears, upon which to rely. I think it would be possible to make some recognizable reconstructions on some skulls from Negro cadavers, but not on most. I am convinced that recognizable reconstructions would be impossible in the vast majority of Whites. Certainly one could not expect that a close likeness to a person's appearance during life could be established from the skull alone.

The face of the cadaver provides an expressionless appearance to which many other cadavers may bear a fair resemblance, an appearance, by the way, which may very little resemble what the person actually looked like during life. Hence the difficulties which close relatives have often experienced in identifying a body after the lapse of a little time.

Omitting size and expression of the eyes, the expression of the face is perhaps something that may never be achieved, and possibly is even unnecessary for the purposes of identification. In Whites, the form and color of hair, size and form of lips, shape of nose, eyebrows and hairline, distribution of subcutaneous fat, and a good many other soft-tissue characters, vary considerably. These bear little or no relation to the skull beneath, and it is precisely these features that give the person his unique appearance. How then can these features be reconstructed in a single person? Accurate reconstructions are not impossible, but, considering the kind of variables involved, they are highly improbable. Further experiments of the kind conducted by Dr. Krogman will finally settle this question. — M. F. Ashley Montagu. A study of man embracing error. Technology Review, vol. 49, no. 6, April, 1947, pp. 345–347, 356, 358, 360, 362.

THE IDENTIFICATION OF THE UNKNOWN WAR DEAD

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The army through its American Graves Registration Service, in its stupendous and unprecedented Repatriation Program, faced with the problem of the identification of the unknown war casualties throughout the world, seeks and utlizes the aid of the physical anthropologist. Obviously, the disinterment of the known dead creates no difficulties other than those involved with removal from original graves, re-casketing, transporting, and final deposition of the bodies either in private or national cemeteries. The challenge of identifying the unknown dead calls for the highly-trained technician with his exact methods.

During the summer of 1946, Dr. Harry L. Shapiro of the American Museum of Natural History, New York, served as Consultant to the Service in Europe, based at Strasbourg, France. Here, in contact with the numerous problems involved with the initiation of the program, Dr. Shapiro helped to work out practical solutions and aided in the organization of satisfactory procedures first adopted by the newly created Central Identification Point (CIP) at Strasbourg. Positive identification of the "unknowns" became a matter of matching exactly the physical data obtained from the bodies with the information known and held by the Army.

The sex, age, race and stature estimations were determined for each body and along with dental chart records, identifi-

[1] Served as Anthropologist, American Graves Registration Service, Central Identification Laboratory APO 957, September 1, 1947 to March 1, 1948.

cation tags ("Dog"), serial or laundry marks on clothing, initialed jewelry, numbered items of issued equipment and occasionally, even fingerprints, helped to form sources of corroborative evidence of identification.

During the following summer, 1947, on the island of Oahu, T. H. in the Pacific Zone, the Central Identification Laboratory (CIL) was set up under the experienced guidance of the same morgue director (civilian) who had helped to organize the first CIP in Europe, and 2 Army officers from the Pacific Zone who had come to the laboratory at Strasbourg to observe the procedures in use there.

Two large interconnected warehouses serve as mausoleums (nos. 1 and 2) where the flag-draped caskets from all over the Pacific are arranged in their original cemetery associations awaiting examination and identification. Honor guards are on duty at all times, night and day. The morgue (working laboratory), conveniently situated in one of the adjacent corners of Mausoleum no. 2, is a light, airy, sanitary, roomy laboratory. It is well equipped with metal-covered tables at comfortable working heights, fluorescent lights, washing and scrubbing sinks, sterilizers, white storage cabinets for supplies, personal lockers and clean "whites" (operating-room gowns and trousers) and showers.

Under Army supervision (1 major, 2 captains) a staff of licensed embalmers, an anthropologist, a dentist, a chemist, a photographer, a fluoroscope technician, batteries of stenographers, typists, clerks and laborers are all engaged in the serious task of furnishing descriptive data to the Army Board of Review which matches and decides identity.

The embalmers, who were trained by the anthropologist in the techniques of measurement and description of the remains, are paired in teams, each provided with clerk-recorders who fill out the official report papers. The morgue director and anthropologist supervise the combined efforts of the teams of embalmers who examine the bodies. The anthropologist, roving from one table to the next, helps to make the more important decisions and to check the reports prepared

by each team, and is responsible for the statements in the report on each "unknown" which he signs.

The embalmers arrange the remains (approximately 98% skeletal) anatomically, chart and describe each part present, eliminate duplications (parts belonging to adjacent bodies), assess the age and race, estimate the bodily size from stature and weight tables[2] and note the occurrence of anomalies like the Inca bone, spondylolysis, bone pathology, squatting facets, etc. All clothing items are carefully examined for names, initials, serial numbers and sizes. Issue equipment (mechanical) with numbers often hold the necessary clues to identity and/or type and rank in service. All remains and wrappings are painstakingly scrutinized by the fluoroscope expert. All findings are carefully entered in the prescribed place upon the official papers forming the report. Marked clothing and contents of wallets containing personal papers are sent to the chemical laboratory where they are gently handled and made legible by chemical means. Important data are photographically preserved, reproduced and included in the report on the case.

The burials of our fallen soldiers differed according to the native customs in a given locality. When an airplane crashed near the villages of natives, the bodies were always accorded proper burial. In some cases this meant cremation, in others simple interment. Cremated remains are systematically sorted in the laboratory by anatomical parts: skull, arm, leg, backbone, pelvis, etc. Any recognized duplication means at least 2 individuals. In large plane (bomber) crashes, the task is to segregate the individual remains of the crew members whose identity as a group is known. This seemingly impossible job is likewise systematically approached in the following manner:

1. All cleaned fragmentary bones, including those of the skull, are mended as completely as possible.

[2] Manouvrier's stature estimation tables and Pryor's weight tables (width-weight scales) were used.

2. The limb bones are paired off on the basis of similarities of size, morphology and muscle markings.

3. Bones showing epiphyseal union or marked by arthritic outgrowths found among others lacking these characters are readily segregated.

4. The pelvic regions are used as the starting points of assembly. Paired innominate bones are articulated with sacra. Then articulating lumbar, thoracic and cervical vertebrae are fitted (articulated) to the proper pelvis, thus establishing "unit torsos."

5. Complete skulls (with articulating jaws) are united with the proper atlases of the completed torsos.

6. Paired femora are placed with the trunks according to the best fit at the hip joints. Final assignment is checked by elimination and repeated trials which demonstrate the impossibility of the thigh bones belonging to any but the selected body. All possibilities are eliminated systematically.

7. Articulating lower leg bones, tibiae and fibulae, and paired knee-caps are assigned by the knee-joint articulation.

8. Foot bones (shoesful of entire feet often preserved intact in socks) are placed with the lower legs through articulating ankle joints.

9. Paired arm bones (articulating humeri, ulnae and radii) through general morphological resemblance and proportion to the already placed leg bones are assigned to the respective "bodies." The bones of the floating pectoral girdle and the ribs proved to be the most difficult ones to place.

10. Paired scapulae are carefully fitted to the humeral heads for size and general overall similarity to the rest of the remains.

11. Paired clavicles are articulated with the scapulae and their respective upper extremities.

12. Ribs are sorted by side, size, general resemblance of texture, curvature, etc.

13. Breast bones (sterna) often may be associated with the placed collar bones.

14. All hand and foot bones not otherwise associated are paired, and occasionally the articulating bones of the necessary chain are found — demonstrating their place.
15. Infrequently glovesful of hand bones occur which are articulated with the distal joints of the lower arm bones.

This procedure, in its complete form, requires that all the bones of all the individuals be present — an infrequent situation. As mentioned before, the age differences characterizing the bones of young men 18–20 years, along with those of size proved most useful in segregating procedures.

In all cases of doubt, all possibilities of a new association of any bone are systematically and patiently explored. Elimination of any other association is also demonstrated before the cases are regarded satisfactory and ready for routine processing.

Unique characters like healed mastoidectomies, healed fractures, squatting facets of the ankle joints, or any other known physical mark are useful in identifying "our man" in a group.

In any case, if the reported laboratory data do not correspond with those of the individual known, the Board of Review rejects the case and asks that it be re-examined. Identification has to be positive!

Rarely an embalmed body is the subject for identification. These cases, often hospital patients, have become unknown through catastrophic agencies like bombing, fire or direct enemy contacts. Body scars, tatooing, morphological features of the head, and even fingerprints may be described.

Ultimately, after positive identification of a case has been established, the body is placed in a permanent type casket and prepared for final disposition.

The experience of examining and describing some 1500 "unknowns" proved to be a highly instructive and fascinating one. It is estimated that approximately 80% of the unknowns are being definitely identified. The author's work and experience with Indian skeletal studies both in Alabama and Kentucky (TVA-WPA) proved invaluable toward the

successful execution of this difficult mission. Thus routine pysical anthropology made possible a practical contribution in the service of the nation.

THE JOURNAL OF THE ANTHROPOLOGICAL SOCIETY OF NIPPON (Zinruigaku Zassi), vol. 59, nos. 675–686, January 1944 to December 1946, contains the following articles (in Japanese) of interest to physical anthropologists:

TANABE, GIITI Kalzium- und Phosphorgehalt der Menschenknochen aus den steinzeitlichen Muschelhaufen von Hobi, Prov. Mikawa. pp. 1–5.

SEKI, KORETERU Ueber die Uebertragung der Handformel nach den neuen Methoden in die Alten. pp. 9–16.

SUZUKI, HISASI Ueber 2 künstlich verarbeitete Menschenknochen aus der Steinzeit Nippons. pp. 25–28.

OMORI, ASAKITI Anthropologische Untersuchungen der Unterkiefer der Kiusiu-Bewohner. pp. 43–72.

KONDO, SIRO Ueber die Querschnittsfiguren der Tibiae der Japaner aus frühgeschichtlichen Zeiten. pp. 90–100.

NOSAKA, YASUTUGU Die Form der äusseren Nase. Anthropologische Untersuchungen der äusseren Nase der West-Koreaner. III. pp. 114–123.

HIRANO, GOKITI Ueber die Zahlenverhältnisse zwischen den beiden Geschlechtern bei den anthropologischen Untersuchungen der vershiedenen Rassen des Ostasiens. pp. 156–178.

SHINOZAKI, NOBUO Die Fingerabdrücke der Mischlingen zwischen den Ponape-Insulanern und der Europäern u.a. pp. 211–227.

SUZUKI, MAKOTO Ueber die Skelette der Steinzeitmenschen aus Hogi in der Nähe von Kainei, Chosen. pp. 228–247.

ARAYA, SIUKURO Ueber die Asymmetrie der Schädel der Koreaner, Chinesen und Mongolen. pp. 262–289.

SUDA, AKIYOSI On the body-build of oarsmen. pp. 291–296.

HASEBE, KOTONDO Ueber die Somatometrie in Ostasien. pp. 302–309.

——— Die 10 mit einem symbolischen Buchstaben benannten Gesichtsformen und "Drachen-Nase" in der japanischen Physiognomie. pp. 311–318.

——— Ueber die in einer japanischen Veröffentlichung für die Chiromantie beschriebenen Handformel der Hautleistenmuster der Finger. pp. 415–417.

WATANABE, NAOTUNE Ueber die kolorimetrische Untersuchung der Haarlösung. pp. 321–341.

MATUMOTO, KIYOSI Die Fingerabdrücke Birmanen und Nepalesen. pp. 343–351.

APPLIED PHYSICAL ANTHROPOLOGY IN GREAT BRITAIN IN RECENT YEARS

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According to the unpopular view, physical anthropology has a cultural aim, and to speak of an applied branch of the subject is almost contradiction in terms. Not to be so particular, applied physical anthropology can be supposed to cover all investigations which relate the methods and data of the "pure" science to any other kinds of problems, whether academic or practical (Clark, '46).

In recent years research of this kind carried out in Great Britain has been concerned chiefly with the application of the techniques, methods of treatment, and records regarding morphological measurements of the body to particular practical problems. These have been personnel problems of the fighting forces concerning relations between groups of men and the spaces in which they work, or the clothes they wear.

Somatotyping in selecting personnel for the British Services has not been a practical issue. Methods used for the purpose in the Navy and Army have been described: tests of bodily agility and manual deftness were used but not morphological measurements (Vernon, '46). The problem of body build has been discussed in several recent papers (e.g. Tanner, '47, where references are given). Results of factor analysis of body measurements of 2,400 R.A.F. flying personnel have been published, and a conclusion reached is that "the distribution of the factor measurements shows a close approximation to the ordinary normal curve" (Burt and Banks, '47).

Records of the medical examinations of recruits have been used in two unpublished researches to give the first satisfactory regional distributions of height and a few other characters within Great Britain, and to provide comparisons of heights and weights of personnel with good medical histories and those invalided for various reasons. A new plastic eye color scale was made for use in an investigation regarding a possible relation between eye color and color blindness (Grieve and Morant, '46).

In considering the recent development of "practical anthropometry" it is convenient to deal first with basic information regarding variation in body measurements, and then with methods of applying it and applications for particular purposes. It may be taken for granted that the treatment of practical spatial problems will always require knowledge of the distributions and correlations of suitable body measurements for the populations concerned.

The classical anthropometric techniques for measuring living people aim primarily at providing a description of skeletal characters. Most of the "points" defined are landmarks on the skin giving as close an approach as possible to underlying "points" on the skeleton. An alternative method of measuring the body is to take suitable over-all measurements of its parts without regard to separate bones. Stature, sitting height, cubit and span are composite dimensions of this kind. In dealing with problems relating bodies of people to spaces they have to occupy, over-all lengths are decidedly more useful than skeletal lengths. The need is for knowledge of the space occupied by the body, which is assessed better by total thigh length and maximum shoulder breadth, say, than by the length of the femur and bi-acromial breadth (Darcus and Weddell, '47; Hugh-Jones, '47; Weddell and Darcus, '47).

The measurements needed in practice are of clothed people. Having carried out a survey giving nude measurements, the allowances to be made for any particular assemblage of clothing can be found by repeating the "over-all" measurements of

a small number of subjects — 10–20, say — first unclothed and then when they are wearing the garments.

During the war, body measurements were recorded for nearly 3,000 Royal Air Force flying personnel and 2,200 Royal Armoured Corps personnel. Body measurements of children, in a survey in progress regarding seating carried out by the Department of Anatomy of the University of Birmingham, under the direction of Professor S. Zuckerman, have been obtained.

Various body girths of a sample of 520 R.A.F. aircrew were recorded in a survey designed to give information needed for clothing purposes. There is little to report regarding new records of measurements of heads, hands or feet. The few British data of these kinds collected recently were obtained by using conventional techniques.

The series of men in the Forces for whom detailed body measurements were obtained were rather small samples representing two special sections of the total population. As a control the heights and weights only of large numbers of men representing several sections of it were reduced and analysed. There is evidence that height and weight are the best pair of measurements that can be used for the purpose. In general the lengths of different segments of the body show their highest correlations with stature — ignoring the case of overlapping lengths, such as arm length and span, which necessarily give high correlations — and girths can be predicted more accurately from weight than from any single girth or other measurement.

In dealing with a spatial problem relating to a particular population, the minimum information regarding body size required is knowledge from a sample of the distributions of heights and weights for the population, age also being taken into account, of course. Given this information, the data of a detailed body measurement survey presented as correlation tables can be adjusted to apply to another population for which only distributions of heights and weights for a sample of adequate size are available. The procedure was normally

on these lines in dealing with special sections of the British population, and judging from test cases the method can be trusted to give results which are sufficiently reliable for practical purposes.

The method of adjustment used really depends on the assumption, justified by experience, that regression coefficients — not correlation coefficients which are affected by selection — are reasonably constant for different populations. Looked at from another point of view, the treatment presumes that the distributions of body proportions are very similar for different populations. There is good evidence in support of this assumption in the case of different sections of the British population, and other evidence suggests that for practical purposes it may be extended to refer to people of European descent in general. A very close agreement is found between relative measurements of the trunk and limbs for United States recent and earlier (e.g. Davenport and Love, '21) series representing communities of mixed European descent and British series. Making allowances for some differences in definitions of measurements, both kinds show close agreement with the classical Swedish (Lundborg and Linders, '26) and Norwegian (Bryn and Schreiner, '29) series. The characters in question can be of little use in making racial distinctions between sub-groups of the total European population.

The data of American surveys have, in fact, been used frequently to give estimates for British populations in the case of body characters not recorded for any British series. Such borrowing is particularly easy in the case of U.S.A.A.F. and R.A.F. flying personnel because the two distributions of heights are so similar that for practical purposes they can be supposed the same. Application of adjusted data for one population to an entirely different population should be more restrained, or not used at all, when weights and body girths, or head measurements, are in question. But in the case of lengths of the trunk and limbs the adjustment referred to can be justified, and it is greatly facilitated when correlation tables are available. Tables with height, sitting height and weight

are most frequently required. Encouraged by limiting research facilities, perhaps, no need is felt at present for new surveys of body measurements of British men of military age. A few hours with a calculating machine can be expected to supply sufficiently accurate answers more economically.

In dealing with a particular practical problem, there is still a need for the control provided by the distributions of heights and weights for a sample of the total community considered. This need is all the greater because there is good evidence for the British population that the distributions of lengths and girths of the body have tended to change in recent years. The conclusions reached by applied physical anthropologists regarding this matter may be of interest to their "pure" colleagues. The following summary of them is based largely on reductions of extensive records collected since 1940 which have not been published.

The matter concerns secular changes in heights and weights for the British population that have taken place in the past 100 years. During the latter half of the 19th century the age curve for height i.e. the "curve" given by average heights at different ages — for the general population showed increase to a maximum at about 26 years. This age remained stable during the 50 years as far as can be told. Series representing higher social classes show attainment of the maximum at earlier ages, and other series (e.g. of criminals and inmates of mental hospitals) show ages above 26. Within a particular class men selected as being physically fitter, such as accepted recruits for the fighting forces, show a younger age than the remainder.

From about 1900 the average age for the attainment of skeletal maturity, judged from the cessation of growth in height, tended to become younger. The trend was slow at first and it must have been accelerated during the last war. The age today is about 21 years, as near as can be estimated for the general population, and Service series show younger ages than this. Throughout the past 100 years the maximum average height — still for the general population — remained practically unchanged, all estimates for different periods be-

ing close to $67\frac{1}{2}$ inches. The change taking place, which was marked enough to be of practical signifiance, was in the growth rate, as records for large numbers of children suggested, but not in the end result.

The British records since 1939 also show appreciable changes in the distribution of weights. The general tendency has been for averages to be well maintained up to some age about 25 years, while for later ages means well below pre-war standards are found. The secular change is quite marked enough to be of practical significance in connection with clothing problems.

Ways in which the information can be applied may be considered next. Experience of this matter suggests the following conclusions and maxims.

1. The data for body measurements alone can seldom be expected to give the complete answer to a particular practical problem. The records are either for parts of bodies measured without regard to attitude, or for bodies held in specified stiff attitudes. By themselves they give practically on information regarding tolerance in clearances, acceptable ranges of movement, or requirements for comfort.

2. The golden rule is: don't guess — try! In order to obtian satisfactory answers trials of one kind or another are nearly always needed. The limitations of practical feasibility will have to be taken into account, and in addition to anthropometric considerations others of a physiological and psychological nature will usually be involved. Body measurements of subjects used in the trials will be required, so that each can be related to the known (or inferred) distributions for the community concerned.

3. The most economical way of conducting the trials is to take all the conditions regarding design and use into account at the same time, so far as this is possible in particular cases. Much labor may be wasted if a particular *ad hoc* investigation accounts for some of the conditions but not for all, or not for the majority, of them. In general the aim is to obtain a final answer for a given set of conditions, and it is a matter of less

importance if analysis of the information collected fails to reveal ways in which different factors were interrelated.

4. As experience is gained in dealing with a particular class of problem it becomes possible to deal more easily and speedily with other problems of the same kind. Some general rules and principles may emerge in time, and special enquiries may be carried out to obtain such general guidance, but they must be flexible in application and with regard to most topics experimental trials are likely to be a permanent requirement.

5. The investigator's task is by no means over when he has obtained an answer which satisfies him in a particular case. The last stage is "selling the idea" to the people in a position to implement the suggestions made. This can usually be done most effectively if trials are carried out comparing an existing arrangement with an alternative new one proposed. It is often very difficult to assess improvement at all precisely, and in general a comparative conclusion — not one on any absolute scale — is all that can be expected.

An anthropometrician cannot be "practical" if he is confined to the study and to the use of such aids as a calculating machine and a drawing board. If his work is to be effective it must be carried out in the laboratory, in the workshop, in the factory and in the field. He will need to contact and collaborate with physiologists, psychologists, designers and users.

Problems relating human factors to the design of a machine are raised to their highest power, as it were, in the case of the cockpit of a single-seat and high-speed aircraft (Morant, '47). The dimensional problem in this case must be as involved as that for any working space situation. If a satisfactory method of dealing with the most complex case can be found then it should be suitable for, and easier to apply to, all other cases. The working space problem may be defined as the determination of the dimensions of a layout which will be equally suitable for all users when all relevant considerations are taken into account.

Considered as a research project, the problem of cockpit dimensions does not begin to take shape until a particular

layout, and a set of conditions which are to be satisfied completely or as nearly as possible, have been accepted. Some of the conditions may be precise (such as ones stating that pilots should have a particular range of unobstructed vision, or that they should be able to operate all controls used in flight while being tightly harnessed to the seat), and others will not be defined precisely (such as ones stating that there shall be proper regard for the safety, ease in operation and comfort of pilots).

The method of experimental trials has been used in practice and it is believed to be the one which can give a satisfactory answer in the most economical way. It can be recommended for use in the investigation of other working space problems, for which the conditions will usually be far simpler. The solution reached will relate to the particular set of conditions. Experence in dealing with the cockpit problem makes it possible to list certain dimensions of the space which should have particular values, with or without tolerance limits. If one or more of the conditions are changed later, it may be possible to infer that some of the dimensions should be changed to other values, but the dimensions are interrelated in complex ways and in cases of doubt further trials should be carried out. It may be noted that the answer is given in terms of measurements of structures. These are what the designer wants, not measurements of men.

The measuring of people for the purpose of deciding how best to make sized clothes started more than 100 years ago, but earlier research of the kind was of very limited scope and value. A clothing survey which aimed at obtaining all the information needed was carried out in 1944. The subjects were 520 R.A.F. flying personnel and records were collected and reduced of their nude body measurements, of their tailoring measurements, of the fitting of standard uniforms, and of the measurements of the garments compared with those they were supposed to have according to the size roll.

In attempting to reach any complete solution of the sizing problem all these factors have to be related. The body meas-

urements alone can give reliable grading of different measurements — they can show, in particular, how girths should be increased with increase in lengths — but they cannot provide the tailoring measurements for a basic size, or indicate how many sizes could best be made. For these purposes estimates must be obtained of tolerances in fitting for certain major measurements of the garments. Errors in manufacture are also important. These may be of the same order as differences between the size roll measurement of adjacent sizes of a garment, and it is doubtful whether they could be made small enough to be insignificant. Another important consideration is the method of distribution of the garments: the advantage of good sizing may be lost if no care is taken to ensure that each recipient gets the garment from stock which will fit him best.

Clothing research on these lines is in its infancy. There is a need for a more thorough statistical investigation of data collected already. The prospect is that a method might be developed which would give a close approach to the ideal size roll in the case of any projected garment. Estimates of the distributions of heights and weights for the community concerned would be taken into account at this stage. Another advantage of using height and weight for the purpose is that it simplifies prediction of the relative numbers of different sizes of the garment that will be required.

The important point to appreciate is that there can be no assurance initially that a size roll worked out on paper will be ideal for a new garment. The only reliable procedure is to conduct fitting trials with a set of garments made up in accordance with the preliminary size roll. These may show that some of the measurements of the clothes, or the number of sizes made, might be changed with advantage, and it is not unlikely that they will suggest that the patterns might be improved. It may be considered advisable to carry out further trials with a second set of garments made up in accordance with a modified size roll.

Experience has shown that the optimum number of sizes for a new garment, and the relative values of different measurements, are dependent on both the style and the materials used. Fitting trials should always be considered essential, with tailoring experts — not the anthropologists — judging the fitting, of course. The evidence of trials, with tailors collaborating as observers, and results given in terms of alterations to garments required to give perfect fitting, is as likely to convince clothing experts as any evidence could. These conclusions can be supposed to apply to garments of all kinds (including head — hand — and foot-wear) and also to oxygen and other masks which need to be sized.

The end of practical anthropometry should be an action, not a thought. In the discussion above the need for experimental trials to determine the best course of action is repeatedly stressed. Such a counsel of perfection is not always followed, perhaps, even by those who are loudest in advocating it, but there can be no doubt that inferences drawn from body measurements alone, without the aid of trials, are quite likely to be misleading. Accounts of particular British enquires of the kind discussed are enshrined — if that is the right word — in official reports, and they are likely to remain in that condition.

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WHY DUBOIS WENT TO JAVA.— In the early years of his search for the forerunner of man Dubois made a collection of teeth from caves in the Padang Highlands, Central Sumatra. It seems necessary to restate the considerations that induced Dubois to seek for the "missing link" in this part of the earth, since even Weidenreich ('42) is not aware of them. They are (cf. Dubois, 1888): (1) the supposition of Darwin, that man has lost his hairy coat in a warm climate, and (2) the remark of Wallace that a study of the cave fauna in those regions of the earth where anthropoid apes are still living today might furnish evidence of the history of descent of man. The alleged occurrence of an ape allied to or identical with the orang-utan in the Siwalik fauna (Falconer, 1868, I, p. 304; II, p. 578) already led Lydekker to the conclusion that the ancestral home of the larger Pongidae was probably the Oriental region . . .

From the close resemblance of the Sumatran cave teeth to those of the species still inhabiting the island Dubois thought this fauna to be too young for his purpose of finding *Pithecanthropus*, and, in 1890, after 2 years' exploration in Sumatra, he set foot on Java, the island which within a few years would supply him the desired fossils. Dubois referred the cave fauna of Sumatra to the prehistoric portion of the Holocene (Dubois, 1891, p. 93) and never returned to this subject in his subsequent papers.— D. A. Hooijer. Prehistoric teeth of man and of the orang-utan from central Sumatra, with notes on the fossil orang-utan from Java and southern China. Zoologische Mededeelingen, Leiden, vol. 29, 1948, pp. 175–301.

Rollet's Table for Stature Determination.— This table, originally published in 1888 and later (1893) modified by Manouvrier, is relatively inaccessible and little known. The bones were measured in the fresh state and represent a series of 50 males and 50 females, many of whom were aged:

Males

STATURE	LOWER APPENDAGE			UPPER APPENDAGE		
	Femur	Tibia	Fibula	Humerus	Radius	Ulna
cm	*cm*	*cm*	*cm*	*cm*	*cm*	*cm*
152	41.5	33.4	32.9	29.8	22.3	23.3
154	42.1	33.8	33.3	30.2	22.6	23.7
156	42.6	34.3	33.8	30.7	22.8	24.0
158	43.1	34.8	34.3	31.1	23.1	24.4
160	43.7	35.2	34.8	31.5	23.4	24.8
162	44.2	35.7	35.2	31.9	23.6	25.2
164	44.8	36.1	35.7	32.4	23.9	25.5
166	45.3	36.6	36.2	32.8	24.2	25.9
168	45.8	36.9	36.8	33.1	24.4	26.1
170	46.2	37.3	36.9	33.5	24.6	26.4
172	46.7	37.6	37.3	33.8	24.9	26.6
174	47.2	38.0	37.7	34.2	25.1	26.9
176	47.7	38.3	38.0	34.5	25.3	27.1
178	48.1	38.6	38.4	34.8	25.5	27.3
180	48.6	39.0	38.8	35.2	25.8	27.6

Coefficients

. . .	3.66	4.53	4.58	5.06	6.86	6.41

Females

140	37.3	29.9	29.4	27.1	20.0	21.4
142	37.7	30.4	29.9	27.5	20.2	21.7
144	38.5	30.9	30.5	27.8	20.4	21.9
146	39.1	31.4	31.0	28.1	20.6	22.1
148	39.7	31.9	31.5	28.5	20.8	22.4
150	40.3	32.4	32.0	28.8	21.1	22.6
152	40.9	32.9	32.5	29.2	21.3	22.9
154	41.5	33.4	33.0	29.5	21.5	23.1
156	42.0	33.8	33.4	29.9	21.7	23.4
158	42.4	34.3	33.9	30.3	21.9	23.6
160	42.9	34.7	34.3	30.7	22.2	23.9
162	43.4	35.2	34.8	31.1	22.4	24.2
164	43.9	35.6	35.2	31.5	22.6	24.4
166	44.4	36.0	35.7	31.9	22.8	24.7
168	44.8	36.5	36.1	32.3	23.0	25.0
170	45.3	36.8	36.5	32.7	23.2	25.3
172	45.8	37.4	37.0	33.1	23.5	25.6

Coefficients

. . .	3.71	4.61	4.66	5.22	7.16	6.66

MEASUREMENTS OF MAN FOR MAKING MACHINERY

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THREE FIGURES

The engineer requires biological information for the solution of many of his problems in making machinery which must be operated by man. The interests of the biologist, however, have always closely paralleled the interests of those engaged in agriculture and in medicine. As a consequence, medicine and agriculture have received continuous and effective support from biology as well as from the physical sciences, chemistry, and mathematics. The biologist has, however, done little for those in the engineering fields.

Quite recently, the need of the engineer for biological knowledge has been re-emphasized by Craig Taylor and L. M. K. Boelter ('47). They proposed that a discipline be established as a part of engineering training, to be called *biotechnology*, for instruction in biological knowledge pertinent to engineering accomplishment. Even before this term was suggested, some major biotechnological contributions had been made. One of these was made by Hooton, Benson, Gagge, Randall, Damon, et al. who applied the technics of physical anthropology to obtain measurements of man for clothing, personal equipment, and for the engineering design (Damon and Randall, '44; Randall, Damon, Benton and Patt, '46).

Even though the pioneer investigation was one of considerable magnitude, and included studies on approximately 3,000 subjects, a formidable task still remains.

The working or operating area is a primary consideration in designing machinery for man. This working area may be merely the space adjacent to an installation, or may be an integral part of the machine. In this latter case the operator's area is limited by practical considerations. Here, especially, the engineer requires certain quantitative descriptions of man. These include:

1. The maximum arm reaches which can be attained by man without altering his position or posture. These measurements constitute a reasonable basis for establishing the maximum boundaries of the working area for the operation of manual controls.
2. The extension of these reaches which can be attained by movements of the trunk or the body. Knowledge of such measurements may be required for special cases in new design, or for formulation of expedient measures in current models where the possibility of structural change is precluded.
3. The eye level of men in the operating position.
4. Dimensions of the body in the operating position, i.e., stature or sitting height, and antero-posterior and lateral measurements at various levels.
5. The leg reaches which can be attained without altering the position of the body or disrupting body posture.
6. The direction and degree of movement of the various articulations which can be utilized for the operation of controls at a biomechanical advantage to apply the necessary force efficiently and to attain the necessary degree of precision of movement.
7. The position of the body to minimize distracting discomfort.

This list is by no means comprehensive, even though the work necessary to establish such quantitative descriptions of man represents an extensive program of investigation. Further, it is pertinent only to establishing the physical dimen-

sion of the work space and to locating operating controls at positions where they may be operated efficiently.

The objective in making the quantitative biological data available to the engineer is to permit him to make machinery which will fit a very large percentage of the population of potential operators. It is completely impractical in the production of complicated machinery to turn out different sizes, as may be done in the case of clothing. As a consequence, statistical treatment of the data is essential to insure that a large percentage of the population can attain the necessary reaches, retain freedom of movement at the established inner boundaries of the work area, and carry out neuro-muscular activities at the levels of work and precision required. Further, the arrangements must be such that the performance of the operators will not be jeopardized by distraction resulting from discomfort.

A brief discussion of a specific study will illustrate one phase of the problem of measurement of man for making machinery. In 1945 a study was undertaken at the Naval Medical Research Institute to determine how far a man in a fixed position can reach in various directions into the surrounding area (King, Morrow and Vollmer, '47). Observations were made on 139 subjects; 79 were naval aviators, 45 from transport squadrons and 34 from fighter squadrons. The remaining 60 were non-pilot Navy personnel.

The testing apparatus for the reach measurements consisted of a Warren-MacArthur pilot seat mounted on a platform and equipped with suitable horizontal and vertical measuring rods. The horizontal arm was pivoted at a point directly above the reference point of the seat. This reference point was taken as the upper level of the seat cushion at its line of intersection with the small lower cushions of the back pad.

The subject reached for and touched successive points on the vertical measuring rod as it was brought toward him by moving it along its horizontal support. Horizontal distances from a vertical line rising from the seat reference point to the

vertical measuring rod at the extreme finger tip reach were measured for each of 99 points.

The population which was used in this study was further described by noting the age, height, weight and 10 physical measurements. The latter data were further employed in the attempt to determine a simple relationship between effective arm reach and the body measurements.

The over-all pattern is such that the average reach increases as the arm is moved laterally from zero to 15, 45, 75, and 105

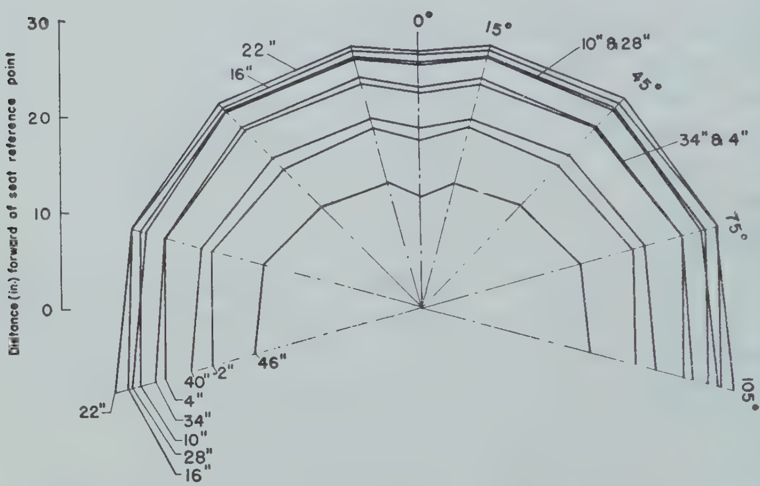

Fig. 1 Maximum distances which can be reached by 97% of the population at each position (° designation indicates degree to right or left, and ″ indicates inches above or below reference point). The elliptical arcs describe maximum boundaries for this group for operation of manual controls at various horizontal levels. Seat back at 13° from vertical (From King, Morrow and Vollmer, '47).

degrees, and decreases as the arm is raised or lowered from the trunk height of the subject (figs. 1 and 2; table 1). The unequal radii of any arc describing various successive points of reach are attributable to the position of the shoulder joint in relation to the midsagittal plans of the body, and to its architecture.

If the arms are extended forward, they intercept an arc at approximately 12 to 15 degrees to the right and left of the

mid line. As the arm is moved more and more laterally, one-half of the chest breadth (at shoulder height) contributes increasing increments to the reach dimension until the arms are extended straight out from the sides. Further, the tissues lying behind the shoulder contribute to arm reach at points forward of this joint; the extent of this contribution decreases

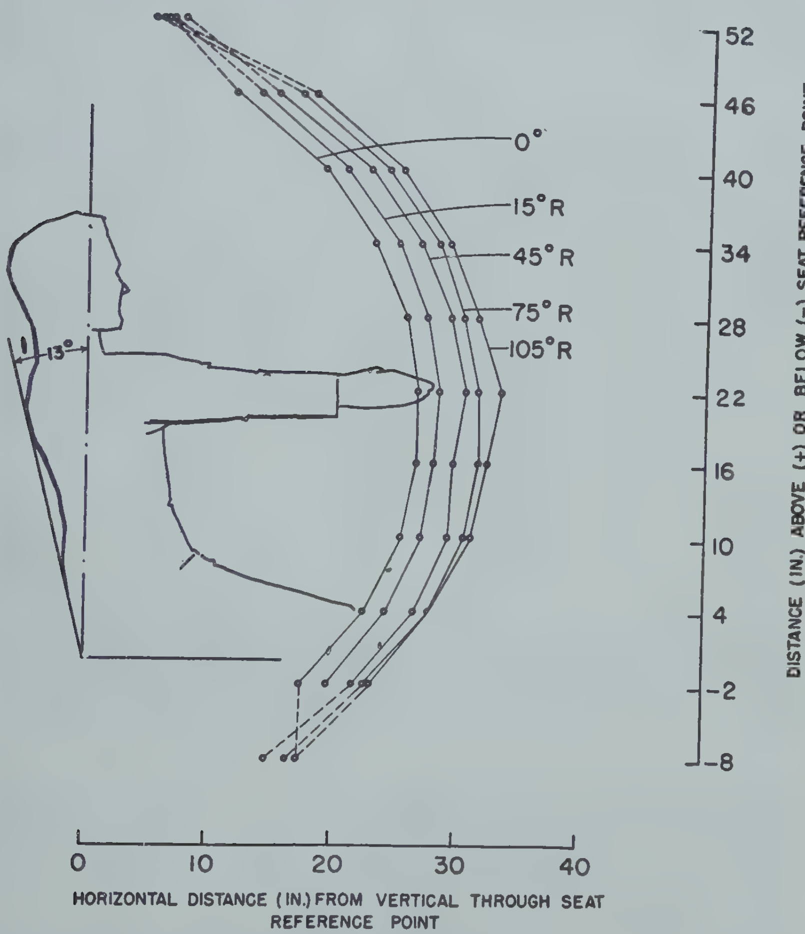

Fig. 2 Maximum distances which can be reached by 97% of the population at each position. The elliptical arcs indicate the maximum boundaries of the working area for operation of manual controls (at various levels, at angles from 0 to 105 degrees to the right) for this group (From King, Morrow and Vollmer, '47).

continuously as the arm is moved from 15 to 90 degrees from the midsagittal plane of the body.

The number of separate reach measurements required serves as an excellent example of the necessity for supplementing the conventional anthropometric measurements in order to obtain data for the engineer.

The distribution of arm reach measurements deviates from normal so that theoretical predictions should not be made by

TABLE 1

The maximum distance (inches) at various points in the boundary area for operation of manual controls which can be reached by 97.73% of the population at each position and 92.9% of the NMRI series at every position; N = 139 (From King, Morrow and Vollmer, '47)

LEVEL (INCHES) ABOVE SEAT REFERENCE POINT	ANGLE (DEGREES)			
	0	R15	R45	R75
46	11.6	13.7	15.0	17.0
40	18.9	20.5	22.4	24.1
34	22.9	24.9	26.6	28.0
28	25.5	27.1	29.1	30.1
22	26.7	28.2	30.3	31.4
16	26.6	28.0	29.7	31.6
10	25.3	27.0	29.3	30.4
4	22.6	24.2	26.4	27.9
—2	17.5	19.7	21.8	22.8

Note: Distances for right arm reach are measured from the vertical line through the reference point with the subjects' shoulders touching the back cushion; seat back 13 degrees from the vertical. R15° stands for 15 degrees to right. Reach for left arm can be outlined by using above measurements at corresponding points to the left of 0 degrees.

methods used for normal distributions. Statistical analysis and study of the nature of the distribution curves, however, reveal that prediction of each reach dimension which can be attained by 97% of the sample population of 139 subjects is justifiable. The standard deviations for the normal curves cannot be used in predicting maximum reaches for smaller percentages of the population because of the positive skewness of the curves.

Because of the nature of the distribution of arm reach measurements and because of numerically small but statistically significant differences in the age, weight and bodily dimensions of random sample populations of men in the military services, it may be expected that the percentage of other sample populations that can reach specific points on the maximum boundaries of the working area will vary for different series (King, Morrow and Vollmer, '47). The absolute differences in these percentages cannot be predicted. Reaches which can be attained by 93% of the NMRI sample (table 1) may perhaps be attained by 75% or perhaps by 90% of the men in another series.

Unfortunately, the several large series of anthropometric measurements which have been reported for men in the armed services cannot be utilized for comparison with the Navy reach measurements since no significant correlation has been found between a single anthropometric measurement and arm reach. Such a relation would be complex because of the relatively wide range of individual variation in arm length, sitting height, chest depth and the "roving" of the mechanical center of movement of the shoulder. If it becomes necessary to establish more precisely percentages of sample populations which can reach any given set of dimensions, the problem can be solved more readily by direct methods.

The value of such basic measurements is well illustrated by the application of these data for the solution of a current problem in Civil Aeronautics. It has been recently proposed that the pilot and co-pilot of transport type aircraft be provided with shoulder harness. This proposal has been questioned by certain operating companies who believed that the pilots would be so restricted in their movements that they would be unable to reach their controls. Part of this objection was due to a lack of understanding of the mechanisms of operation of the shoulder harness, which has been used so extensively by the armed forces.

The answer to the problem of how much extension of the shoulder harness was required to permit pilots to reach their

aircraft controls was obtained by relating measurements describing the location of the aircraft controls to the results of the reach measurements. The location of the control was described in terms of horizontal distance from the reference point (of the seat), the distance above or below the reference point, and the angle to the right or left of the midsagittal section of the pilot. In addition, trials were conducted on one or two pilot subjects in order to visualize the situation for each aircraft.

The cockpit was divided arbitrarily into 7 areas and the most inacessible control in each area was chosen. The results of surveys on the DC-3, DC-4, DC-6, Martin 202 (fig. 3; table 2) and the Constellation demonstrated that the present standard extension of 18 inches will allow pilots to reach forward or to the side and grasp and operate all controls.

The value of basic descriptions of man is great, as such descriptions have application for the solution of many problems. If, however, the anthropologist is to undertake the task of supplying such quantitative data on man, it will be necessary that he consider the position that the man will assume in operating his machine in relation to the standard conditions established for physical anthropology. In many cases he will have to establish new positions for measurement, or modify the more conventional standard postures. The conventional position which has been established for measurement of sitting height serves as an excellent illustration; this posture is assumed by a pilot only in the presence of an anthropologist. Further, special treatment of the data is required. In problems of engineering design the average value cannot be employed directly, since, by definition, arrangements based upon an average would be unsuitable for 50% of a normally distributed series of values. The concern is not with a comparison of 2 series to establish a fundamental relation, but with providing arrangements that will be suitable for the greatest possible percentage of a population of potential operators.

Perhaps it is unfair to require the anthropologists to carry through on the application of their results. There would ap-

ARM REACH MEASUREMENTS
IN RELATION TO CONTROLS IN THE MARTIN 202

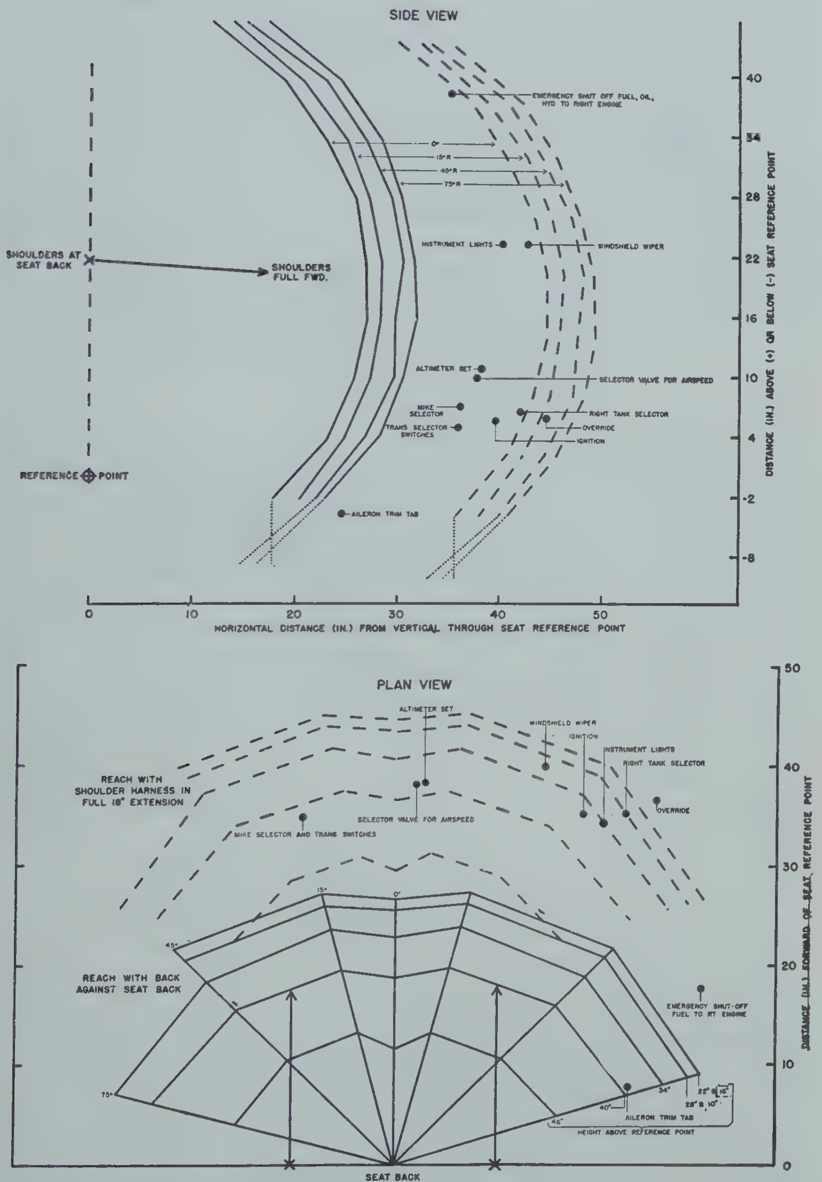

Fig. 3 The positions of various controls in the Martin 202 aircraft. Solid lines represent maximum boundaries of the working area for the operation of manual controls suitable for a large percentage of any pilot population; broken lines show extension of those boundaries which results when shoulders are moved forward the full 18 inches permitted by standard Air Force-Navy shoulder harness.

TABLE 2

Location of aircraft controls in the Martin 202; extension of shoulder harness required for a particular pilot to reach controls

AREA AND CONTROL	DISTANCE FROM REFERENCE POINT [1]		DEGREES RIGHT OR LEFT [2]	EXTENSION FOR SHOULDER HARNESS REQUIRED FOR MOVEMENT OF PILOT "SMI"[3]
	Horizontal	Vertical		
	inches	*inches*		*inches*
Area 2. Control pedestal — upper half				
Right tank selector	42	+ 6	R-33	15¼
Ignition	39½	+ 5	R-27	13½
Over-ride	44½	+ 5	R-35	16¼
Area 3. Control pedestal — lower half				
Aileron trim tab.	24½	— 4	R-72	0
Area 4. Main instrument panel				
Altimeter set	38	+ 13½	R-4	9¼
Selector valve for air speed	38	+ 9¾	R-3	9½
Area 5. Instrument panel — upper portion				
Windshield wiper	42½	+ 23½	R-20	12¾
Instrument lights	40	+ 23½	R-31	9
Area 6. Overhead instrument and switch panel				
Emergency shut-off fuel, oil, hyd. to rt. eng.	34¾	+ 38½	R-60	10
Area 7. Side control panel				
Mike selector	36	+ 6½	L-15	9¼
Trans. selector switches	36	+ 4½	L-15	8¾

[1] Pilot seat at mid-horizontal and mid-ventral adjustment.

[2] Midline of pilot's body (midsagittal section) at zero degrees.

[3] This pilot's arm length is indicated by his sleeve length: 32 inches.

pear, however, to be no other solution since the corrections which would have to be applied in order to perdict the measurements applicable to man when he is permitted freedom in assuming his posture cannot be undertaken by the engineer. It can only be urged that the anthropologist acquaint himself with the engineer's problem and report his results in such a form as to make them interpretable and applicable by the engineer. This would in no way detract from the dignity of basic research. It would only mean that the investigator, having chosen his problem in accordance with his interests, is asked, upon completion of his study, to aid in the utilization of his findings in improving conditions for man.

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Dealers in Tentative Conclusions.— Human bones are constantly being found; sometimes under curious circumstances, and sometimes with even stranger results. During the Middle Ages, someone excavating for a house in the city of Milan in Italy uncovered 2 human skeletons which had been painted red. The parish priest called into consultation in the matter hesitated only a short while before identifying them as the mortal remains of St. Damion and St. Barnabas, I think they were, a brace of early Christian martyrs who had rated

top billing at some long-forgotten Roman holiday. Over them was promptly erected a chapel, which still remains. Bone men of the present time are not so sure of the identification, however, for it is now known that it was customary at the end of the late stone age to daub the skeletons of their distinguished dead with red ochre before interment. It may well be that 2 stone-age men have been puzzling for the past 1000 years at their strange surroundings.— George Woodbury. The man about the bones. Archaeology, vol. 1, no. 2 (2), June, 1948, pp. 105–109.

INEXPENSIVE PROJECTION TECHNIQUE.— Under various names [photoplanation] has been known for a long time as a versatile method of mensuration which lends itself particularly well to the measurement of easily deformable objects, to objects of very irregular shape, or to specimens exhibiting transient or variable forms . . .

Essentially the technique of photoplanation consists in the employment of a beam of pure parallel light, substantially devoid of crossfire or abaxial rays, to cast a shadow of the object to be measured in such a fashion that the shadow will bear a dimensional relation of one-to-one to a plane projection of the object.

Such a shadow may be caused to fall on any suitable scale, grid or rule placed normal to the light beam and the shadow, of course, undergoes no change of dimension due to the act of measuring it. Usually the shadow of the object and the simultaneous shadow of a suitable transparent scale are caused to fall on a sheet of photographic paper or other photosensitive surface to obtain, by ordinary development and fixation processes, a permanent record which is suitable alike for observation, illustration, subsequent reference, or statistical compilation.

The reason that the technique has not been employed more widely heretofore has been the lack of a suitable simple light source . . . During the . . . war research workers at the Western Union Company's Research Laboratories at Waterville, Long Island, New York, developed a new light source which is so small mechanically and so brilliant optically that it forms a useful source of substantially pure radial illumination and thereby lends itself to simple and comparatively inexpensive photoplanation.— Arthur Carpenter. Laboratory photoplanator. Med. Dept. Field. Res. Lab., Fort Knox, Ky., Proj. no. 6–64–12–05, (Subproject under Study of Body Measurements as they Affect Physiological Efficiency), April, 1948, 4 pp. and 14 figures (mimeographed).

ANTHROPOMETRY AND APPAREL

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My experience indicates that the mass production of ready-to-wear apparel might satisfy the needs of the American people better, if physical anthropologists could direct some of their thoughts and energies to the needs of the apparel industry. The purpose of this paper, therefore, is to indicate the nature of the needs of the apparel industry, and to encourage thinking in terms of those needs, when plans are made for studies and research in the future.

The National Bureau of Standards, of the U. S. Department of Commerce has not suddenly become interested in anthropology as a part of its official function. The Bureau is interested in this subject only because its standardization activities temporarily require it.

Perhaps many persons are not aware of the fact that in the National Bureau of Standards there is a Commodity Standards Division, devoted to cooperation with the trade in setting up voluntary standards for commodities on a Nation-wide basis. These standards vary considerably in their application, but they cover terminology, grades, sizes, and use characteristics of manufactured products. Up to the present time the Bureau has helped business set up 147 commercial standards. Among others, the Commodity Standards Division is at present helping business to develop a series of commercial standards for the sizing of ready-to-wear apparel — for children, for teens, and for adults — and is using anthropometric data to guide their development.

There are not many commodities that have a closer relationship to man and his physical measurements than his ap-

parel — his underwear, his hat, his gloves or his socks. For example, men's shirts are sold by anthropometric data — (1) neck girth and (2) length from cervicale to the distal end of the ulna, taken with the elbow flexed. However, there has been surprisingly little done in the development of an interrelated system for sizing apparel, based upon scientifically accurate anthropometric data. Empirical knowledge has been the principal basis for sizing in the past.

For over 15 years the National Bureau of Standards has helped industry set up standards for ready-made clothing, but strange as it may seem, there is no reference in any of the earlier garment standards to the size of the body that is being fitted.

The manufacturer knows that a pair of pajamas, or a slip, if made to conform with certain measurements will fit people. However, very little attention has been given to defining which people. Obviously, if no one defines what people can be fitted with what size, it is not possible to make much progress in the field of apparel standardization. There is no basis for carrying the message to the ultimate consumer.

To bring the proper customer and the proper garment together there should be common definitions for size, and these definitions would be most practical in terms of body measurements, whether clothed or unclothed. That is the nature of my work — to help industry develop such definitions and to put them to use on a Nation-wide basis — as commercial standards.

Why hasn't this been done before? There are many reasons. The principal one, however, has always been the impact of fashion upon the apparel industry. Producers seem to have considered that standardization was incompatible with the changing moods of fashion. Besides, standardization seemed to imply restrictions on the freedom of the producer. Last, but by no means least, was the notion that the infinite variety of human bodies in the population made standardization difficult if not impossible.

There are other reasons. One of the most important is that the apparel industry, astonishingly, has had a kind of substitute for the human body. I refer to the "stand-ins" one sees in the fitting rooms of the dress producers, the coat producers, and others. They are called model forms. The further significant fact is that so much reliance has been placed on model forms as a basis for size, that the relationship between the model form and the measurements of the body has never been fully explored and defined.

The model form is a highly specialized fitting tool. It is not a human body. It only represents a clothed human body. It is inflated through the chest to represent a slightly expanded chest; it is extended a bit beyond the normal outer shoulder point, to be consistent with the expanded chest and to provide width across the back for body and arm movement. This applies rather broadly to all model forms.

In the case of women's model forms the bust, waist, and hip characteristics of the body have also been modified. There is an assumption, for example, that the average woman wears a girdle and a brassiere. Before the advent of the "New Look," it was assumed that the girdle tended to slenderize the hips, pushing the flesh upward toward the waist; likewise it was assumed that the brassiere would not only raise the breasts, but would also increase the bust measurements slightly. The "New Look" seems to have discarded some of these ideas in favor of new modifications of the body.

The significant fact remains that to those in the trade size has meant a "model form" marked a given size and a garment to fit that form, not a living individual with given body measurements.

The most troublesome fact, however, is that size did not mean the same thing to all producers. In fact the variety of size measurements became so troublesome, that the large mail order distributors decided to do something about it. They decided to request the cooperation of the Commodity Standards Division of the National Bureau of Standards. The Division

has been working steadily since 1944 to help them solve the problem.

Early in this relationship, a few basic decisions were made. Since they have proven to be very significant, and should be particularly interesting to physical anthropologists, they are worthy of noting here:

1. It was decided to base all new decisions about size on reliable anthropometric data.
2. It was decided to base the new system of sizing on the best analyses of anthropometric data that could be found.
3. It was decided to begin at the beginning — when the child was born — and work toward maturity.

From the above, it is clear that I am a believer in the use of anthropometric data as a basis for any system of sizing apparel.

However, it is one thing to believe in the use of anthropometric data. It is quite another to obtain such data. In fact, despite my searchings, and consultations with competent authorities, I never did find as much data as is needed in sizing work, particularly as regards children under 4 years of age.

The following are some of these needs: more data about the back of the child; about its girth measurements; about cervicale measurements — up, down, and around; about the waist of the child; and about the ontogenetic changes that occur when children begin to stand erect and walk, instead of creep and crawl.

I have searched diligently, for example, for cervicale length or height measurements. I found only the most meager data. I came to the conclusion that physical anthropologists found it more natural, and more obvious, to take measurements of babies, while they were lying on their backs. I am not urging that the baby be turned upside down, but I am suggesting that a way be found to take a few more measurements than have been taken traditionally.

As regards women's apparel, the ready-to-wear industry fits many body types beautifully. The industry is increasing

the number of body types for which it makes apparel. However, size is still largely undefined, and there is a great variety of size measurements. Further, analyses indicate that the system of sizing is not as comprehensive as it might be.

In the field of women's apparel, the need is for more basic data of the kind recently undertaken under Dr. Randall's direction on Army personnel. These refer not only to measurements of the trunk, but also the extremities — the head, the hands, and particularly the feet. Preliminary discussions with trade association secretaries indicate a need for a modernization of shoe lasts, which, like model forms, are specialized fitting tools of the shoe industry.

The widespread needs for anthropometric data are particularly apparent to a person like myself who has an opportunity to see regularly the requests from the apparel industry for size data of one kind or another. If more raw anthropometric data are made available, the necessary statistical analyses will eventually be obtained.

We realize fully the inherent difficulties in obtaining measurements of large numbers of women in the civilian population. However, without such data no really constructive work can be accomplished. The basic research should be done by the scientist — in this case the physical anthropologist. A modus operandi should be developed between the scientist, the applied mathematician and the technologist.

There are considerable data available about girls and boys from 4 to 17 years of age. This is due largely to the vision of Miss Ruth O'Brien, who is now Deputy Chief of the Bureau of Human Nutrition and Home Economics of the U. S. Department of Agriculture. She realized the inherent possibilities of such data for apparel sizing work, and did something about it. She supervised the well known studies on "Body measurements of American boys and girls for garment and pattern construction," and its counterpart on "Women's measurements for garment and pattern construction" (O'-Brien et al., '41a, '41b).

Without these fine studies and the statistical analyses that go with them, it would not have been possible to develop apparel sizing recommendations comparable to those now completed.

It is not always possible, however, to anticipate industry needs. In 1941, when the first of these studies was issued there was beginning to be developed in the apparel industry special sizes for the girl "teen agers." It was then a relatively new concept, but even today the concept has not been defined adequately in terms of her body measurements, and her clothing needs.

Through the courtesy of the Agricultural Research Administration of the U. S. Department of Agriculture, the National Bureau of Standards has been permitted to duplicate their anthropometric data for girls, which are punched on cards for machine analysis. The Bureau is now anlayzing these data to help the industry develop a commercial standard for sizing the teens' classification of ready-to-wear apparel. Besides the basic raw anthropometric data, which are already punched on the cards, the Bureau needs:

1. To determine a statistical measurement, or definition, of a "teen."
2. Statistical analyses to determine the most predictable criteria — those measurements that prove to be best indicators of other body measurements.
3. To determine the variety of body types in the population.
4. To know the number of persons of each type in the population.
5. Some knowledge of geographical and racial differences.
6. Studies based on criteria of fit, e.g., posterior waist length versus stature, as the key vertical measurement in obtaining a good fit in a dress, etc.
7. To consider the impact of industrial technology upon the statistical data. Standards require voluntary acceptance by producers, and voluntary acceptances signify that a practical wedding of industry practice and mathematical determinations has been achieved.

The assumption is, however, that when the final size recommendation is drawn up it will provide a system of sizing which will assure the best possible fit for the maximum number of teen-age girls.

The best evidence of the practicality of this form of collaboration is the fact that the dress pattern industry has used body measurements as a basis for sizing all of its apparel since its earliest beginnings. It standardized its terminology over 15 years ago.

The mail order industry has been using body measurements for the sizing of its ready-to-wear apparel for more than a decade. They have already adopted the measurements in the 3 completed sizing recommendations developed in cooperation with the Commodity Standards Division. Use by these companies of uniform definitions for size in their respective catalogues indicates the practical possibilities of the use of anthropometric data. I urge the reader to examine the sizing pages in the large mail order catalogues, and to compare the sizing data with those in the Bureau's recommendations.

I shall not spend time speculating why anthropologists, and clothing technologists, have not put their heads together more often in the interest of better fitting clothes, both for children and for adults, but I can urge that there is no better time than now, and I can suggest what might be done to bring the groups together.

Recently the mail order sizing committee, with which the Bureau is cooperating, decided to draw up an outline of the scope of the committee's work. This is to include what has already been done, and what is planned for the future. This will not cover all subjects of interest to physical anthropologists, but it will indicate the needs of 1 group. As requests for cooperation on other standardization projects are received, they can be added to the list, so that anthropologists will be able to learn of those problems which require more anthropometric data, thus coordinating the needs of business with the research programs of anthropologists. Perhaps the American Association of Physical Anthropologists or the Smith-

sonian Institution will use its good offices to effect the desired coordination.

The Commodity Standards Division of the National Bureau of Standards works only on projects officially requested by some responsible organization. This insures that cooperation based on these requests will always be on projects of genuine public interest. The cooperation of the National Bureau of Standards can be counted upon to the extent of its functions, in keeping the American Association of Physical Anthropologists informed of all its new projects in the apparel field, or in other fields where anthropometric data would be useful.

To cooperate in the manner indicated it is not contemplated that physical anthropologists should abandon any measurements that have proven valuable in their work. It is only being suggested that by giving a little thought to some of the practical needs of industry, and by consultation with those who work closely with industry, or with industry representatives themselves, that 2 groups of persons — the scientists and the entrepreneurs — may be better served merely by the taking of a few additional measurements.

The Bureau of Human Nutrition and Home Economics of the U. S. Department of Agriculture has acquired considerable prestige and publicity for its work on the sizing of apparel, based on anthropometric data. Other organizations and especially colleges, might likewise acquire prestige and publicity for the excellence and high quality of its research, particularly if it also supplied some specific need of the apparel industry.

In summary, I should like to stress the advantages of cooperation between physical anthropologists and technologists in the apparel industry. The groups themselves have done little to date about cooperating, for the reasons given above. Now that the practical value of body measurements as a basis for size standardization has been demonstrated, industry will want to size more and more of its apparel that way.

It is obvious that if continuous research along these lines were undertaken, a considerable volume of anthropometric

data would gradually be developed which would, if deposited in some central clearing agency, provide a large amount of highly practical data.

Physical anthropologists will find in the field of apparel close commercial associates, for the apparel industry clothes the bodies they study and measure. Why should there not be cooperation for the good of the ultimate consumer? I believe there should. I would certainly like to see it tried.

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HENRY FIELD recently returned to Washington after 7 months in Egypt, the Sudan and Kenya, where he served as physical anthropologist of the University of California African Expedition. During his stay in the Near East he secured anthropometric data on the following series: In the Faiyum, 495 (189 in Tamiya and 306 in Fidimin); in Sinai, 223; between Wadi Halfa and Khartoum, 107; near Nairobi, 150. Analyses of these data are being prepared for the Ex-

pedition's "Scientific Series" to be published by the University of California.

An account of several programs of the Expedition can be found in Science, vol. 107, June 25, 1948, pp. 666–670.

CRANIO-CEPHALIC RESTORATION.— During the past 2 years the Illinois State Museum has been engaged in the restoration of heads from the skulls of prehistoric Indians who once roamed Illinois. In this work the 3 writers of this paper have cooperated. Frost doing the modeling, McGregor doing the archaeological validation, and Krogman the anatomical detail. A total of 16 such heads have been produced from carefully selected Indian crania representing males and females of various known tribal groups . . .

The 3 authors, working together over the past few years, have succeeded in adding certain refinements to the process . . . Although not completely satisfactory, the progress made in these studies has been gratifying, and, we feel, profitable.

1. *Relation of eyeball to bony orbit.* The apex of the cornea, when viewed from norma frontalis, is at the juncture of 2 lines, 1 drawn from the medial edge of the orbit (maxillofrontale) to the lateral margin of the orbit (ectoconchion); the other line bisecting the orbit between the superior and inferior margins.

The outer point of the cornea is approximately tangent to a centrally located line drawn from the superior and inferior margins of the orbit.

2. *Nose tip.* (Modified more or less by racial type, and contours of underlying bony structure.) The width of the bony nasal aperture, in Caucasoids, is about three-fifths of the total nasal width as measured across the wings.

The projection of the nose is (from subnasale to pronasale) approximately 3 times the length of the nasal spine (as measured from the lower margin of the nasal opening to the tip of the spine). The nasal spine is, however, rarely completely preserved.

3. *Location of ear.* The most lateral part of the cartilaginous portion of the ear-tube is 5 mm above, 2.6 mm behind, and 9.6 mm lateral, to the most lateral part of the bony portion of the ear-tube . . .

4. *Width of mouth.* The width of the mouth is approximately the same as interpupillary distance; or, alternatively, the distance between 2 lines radiating out from the junction of the canine and 1st premolar on each side.

5. *Length of ear.* The ear length (from top to bottom) is often roughly equal to nose length. (Ear size and proportion are extremely variable.) — Wilton Marion Krogman, John McGregor and Bartlett Frost. A problem in human skeletal remains. FBI Law Enforcement Bull., vol. 17, no. 6, 1948, pp. 7–12.

POST WAR ANTHROPOMETRY IN THE AIR FORCE

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During the past war, tremendous demands were placed upon the team of anthropologists at Wright Field. The results compiled by Randall, Damon, Benton, Brues, and Patt, were admirable in both their diversity and their excellence. A clear and full account of their wartime activities has already been published (Army Air Forces, '46).

At the time of writing the Anthropometric Unit consists of the writer, an anthropometrist; 1st Lt. J. W. Colgan,[1] an army doctor; S/Sgt. J. D. Hazen, a gadget builder; and Hans H. Amtmann, a German scientist who formerly was a designer for Blohm and Voss Aircraft Company of Hamburg, Germany. This may seem at first to be an odd assortment of personnel for an Anthropometric Unit, but actually it has proved effective and fruitful as a team.

UNIT ACTIVITY

General

To readers of this journal the principles of applied anthropometry may seem so obvious as to need no emphasis. While it is true that the gospel of Hooton, Randall and his group, and others have received wide publicity and acceptance, especially in the aircraft industry, there still remain many anthropometric heathen among the engineers, to judge them by the false idols they set up and worship so fiercely. This is true in certain instances even at Wright Field, especially among

[1]Lt. Colgan has since been transferred to hospital duties.

the producers of technical accessories, such as radio and radar equipment. Such designers have never before had to think of the operator's comfort as bearing on the excellence or efficiency of the product. To instill this awareness, we find that we must constantly press our missionary work for the cause.

This crusade takes numerous forms. It permeates our correspondence, of course, and it appears at conferences involving design problems of many kinds, and especially at airplane inspections where the cockpit mock-ups (or full scale working models) are closely scrutinized for orthodoxy. All these are more or less routine activities, and they use up a good deal of time. I mention them only to indicate that our office is not at all a monastic retreat. Our work in general is profoundly practical, and geared to the current activities of many other agencies. But we also carry on a considerable amount of research, all of it to provide results of specific interest to the Air Force. I wish to describe very briefly some of this research to indicate the variety and unconventionality of the methods necessary in this work.

Research

Aside from being a reference library of previously compiled information, the Aero Medical Laboratory has the responsibility not only to carry out short-term research for new data to be applied in current design, but also to foresee trends in military aviation and to provide knowledge likely to be needed in future developments. Most questions addressed to the Anthropometric Unit can be answered by consulting and interpreting existing data. Despite the extensiveness of present information, however, it does not cover all contingencies. Some questions require original research which may take either, or even both of, 2 forms: the static form, or purely dimensional description of the human body; and the dynamic form, or muscle studies, wherein are collected not only the maximum forces that pilots can exert, but also the torque at various measured increments of the total angle or linear distance, through which the limb can travel. It is clear that the bulk

of present data on the human body falls into the static category.

The cone-of-vision study in the fighter cockpit is one example of the static research we have done recently. In all fighter airplanes, an optical gunsight is fixed in the cowl in the center-line of the cockpit some distance in front of the pilot's normal eye position. To design a more efficient gunsight, optics engineers needed to know the pilot's cone of vision through the gunsight. Anthropometrically, the question boiled down to the distance a pilot could move his head in the small space sharply limited by seat, sides and cockpit canopy. It was obvious that tests would have to be made in an actual fighter cockpit. To simulate wartime conditions, moreover, it was necessary for subjects to wear full combat equipment, including the so-called crash helmet, which is somewhat similar to a football headgear. Preliminary trials showed that it was extremely difficult by conventional methods of measurement for a man on the outside of a closed cockpit to locate in space the eye of a pilot inside the cockpit. The method finally adopted was to fasten a specially-fitted sheet of stiff plastic vertically inside the closed cockpit at some convenient but known distance in front of the pilot's normal eye position. He would then move his body around the periphery of his cockpit space while looking through the gunsight, and at predetermined intervals would mark the intersection of his line of sight on the plastic sheet. By connecting the resulting points, each man's cone of vision was established by trigonometry. We used small, medium, and large subjects and found that variation in body size had no significant effect on the angle of the cone, as the seat could be adjusted for differences in sitting height. All that really counted was the size and shape of the cockpit. We have found the principle of interior measurement described here to be exceedingly useful, and that some application of it crops up frequently.

The most important static project undertaken in the past year has been the prone position study. Since about 1936, this problem of the prone position for pilots has received at-

tention from numerous workers in several countries, including Randall at Wright Field, always with military ends in view. There are 2 major reasons for such activity. Designers have long demanded smaller fuselages, even at the expense of the pilot's comfort, because decreased air resistance means greater airplane speed. A prone pilot, moreover, possesses a greatly increased tolerance of high gravity, or high *g*, which means that he can turn sharper and faster than his conventionally seated adversary without experiencing "blackout," or failure of vision and even unconsciousness due to drainage of blood from the brain and eyes. In all of the rather numerous previous experimental attempts at prone flight, however, these great advantages have been negated by the pilots' rejection of the position because of the extreme discomfort of even short flights in the cockpits hitherto provided.

The reasons for this discomfort are inherent in the change from a normal to abnormal line of sight. To sit erect and look straight ahead is normal and comfortable. To lie prone and still look straight ahead calls for severely increased cervical and lumbar curvatures. These become unendurable very quickly. Other rapidly-appearing sources of distress are those so-called "pressure points" or body areas unaccustomed to carrying body weight, such as the chin, the hips, elbows, knees and toes. The first step in utilizing the admitted advantages of the prone position, therefore, is to provide a bed which is comfortable for at least the length of time that a modern military airplane is likely to be flown on missions.

In the search for a suitable bed material, we considered all the usual substances: formed wood or metal, cloth straps, foam rubber, and the like. All had disadvantages. We finally found the answer in a bolt of nylon netting. This netting was light, cool, and very strong (it can hold a 200-pound man up to 150 *g*, or the equivalent of about 30,000 pounds), and yet it was flexible enough to adjust itself to any body shape. We developed a supporting frame inclined so as to hold the torso at an angle found by previous investigators to retain high *g* tolerance and yet to reduce to an acceptable degree the excessive

cervical curvature of the full prone position. We eliminated lumbar fatigue by allowing the thighs and knees to drop into a depression, thus flattening the back. We found that positive abdominal support was essential; so, to accommodate all sizes of men, we designed and installed a pair of cams which could move up and down vertically to vary net tension under the abdomen, and at the same time swing toward head or foot sufficiently for all torso lengths. A pair of foot pedals permitted adjustment of the bed length for any stature, after the shoulders had been placed in a specified position. Bed frame curvature in general was designed so that the netting over it would conform as closely as possible to relaxed body contours. By repeated tests and modifications, we have finally developed a bed upon which 18 men of all physical types and sizes, 10 of them pilots, have each lain for at least 8 hours. A number of these men have volunteered the opinion that they could have continued to 12 or even 16 hours if they had only had something to do. Indeed, we have found that the major complaint was neither fatigue nor discomfort, but simply sheer boredom, which, by the way, we combatted successfully by the use of moving pictures. Our test series covers a range actually greater in stature and weight than that of wartime Air Force Personnel.

This is only the start, however, because we must now consider all the problems of actual flight aside from comfort. It will be a considerable time before the prone position bed can be thought of as perfected.

Because the prone position is unconventional for flight, special controls have had to be designed and new measurements taken for the purpose. Inasmuch as we wanted the control under the man's chest, rather than in front of him, we needed to know the distance from the surface of the chest to the point of the elbow, when the upper arms were held roughly perpendicular to the torso. We had to construct a special measuring board which could be set firmly in place on the edge of a table. The subject leaned his torso against the side of the board and placed his upper arms upon the top, with

his forearms extending upward. It was then a simple matter to read the chest-to-elbow distance directly from the millimeter scale by means of a right-angled block at the elbow.

The elbow-to-palm distance was also needed for the same study. A pistol-grip handle was mounted at one end of a measuring board, so that the subject's hand could grip the handle while the forearm was extended upon the board. Grip-to-elbow distance was thus quickly obtained.

These few examples are sufficient to indicate that static measurements nowadays frequently demand unconventional methods and tools because the requirements themselves are new and unconventional.

The field of dynamic measurements, usually called muscle studies, was perceived during the war by Randall and his co-workers, but was touched upon only slightly. Previous studies had generally included only maximum forces.

To date the Anthropometric Unit has carried out some studies of this type and has plans for much more extensive investigations. The shortage of personnel, however, and the relatively low priorities of such projects have tended to leave them in the shadow of more immediate investigations.

One dynamic project was the "hand torque" study. This was originally undertaken to aid in the selection of the most efficient types of valve handles for use on gasoline trucks. We obtained various types of valve handles, attached them to a torque wrench locked in a vise, and requested the subject to turn the handle as far as he was able. The torque exerted was shown on the indicator dial of the wrench. Theoretically the best form would be that permitting the greatest torque application. We carried our apparatus from white-collar groups to shop personnel to obtain a stratified sampling. Astonishingly enough, the highest torque scores were made by white-collar men! Other results of this study have also been very interesting. Among other things, we have found that many widely-used knobs could scarcely have been made worse, and that new shapes could be designed with greatly improved efficiency. The ideas, moreover, of nearly all subjects as to

what constituted a good handle previous to the tests were found to differ profoundly from their actual results. This may explain why valve handle designers have turned out so many pretty but virtually useless knobs.

Another dynamic project, much more comprehensive, was the so-called "brake-pedal angle-and-torque" study. The problem was to determine the best — that it, the most efficient — angle for the brake-pedal with respect to the floor in cockpits of specific sizes. As before, a torque-indicating wrench was connected to a special pedal which was movable through an arc large enough to accommodate the flexion-extension angle of the foot of any subject. In addition, torque measurements could be made at any 5° fraction of that arc. The subject was correctly adjusted to the cockpit and then was requested to exert pressure on the pedal at various angles. In addition, measurements of leg position were made at certain selected pedal angles. It was found for a number of pilots that there was a well-defined angle in the total flexion-extension arc where torque application was at a maximum. This peak indicated the proper setting of the brake-pedal for greatest average efficiency under the given cockpit conditions.

The project just outlined is only a small part of a study that should be done on the entire human body. How complex this can become will be understood when one realizes the range of possibilities existing, say, in the numerous simultaneous motions of the arm. In a single rapid and accurate movement, for instance, the pilot's right elbow may move forward and outward from his body, the elbow angle may increase, the wrist may rotate and bend, and the whole arm cross over the body. In a wheel-controlled airplane, just such a movement is necessary to make a rapid diving turn to the left. The analysis of muscle action and charting of muscle power for this movement will be anything but simple.

To exemplify the need for this study of arm power more specifically, I wish to mention the Amtmann airplane control. This control — the lever mechanism upon which the pilot exerts muscle force to steer the airplane — has been designed

specifically for use with the prone position bed. In this control system, all of the control surfaces — the rudder, ailerons and elevators — are activated by the hands alone. In fact, the airplane with this system can be operated by only one hand, if desired. The wind pressures on these surfaces in a high-speed airplane are very heavy, and so the question arises whether, in spite of the whole bag of designer's tricks to provide mechanical advantage, the pilot will be able to activate the control surfaces by his own muscle power. We are now having a sample control built for installation with a prone position bed in an airplane. To engineer the control properly for the airplane, however, we must know in advance the forces a man can exert. We have therefore constructed an instrument to measure torque laterally in the horizontal plane — in this case, rudder control motion — but we have not yet completed a device for measuring torque in all 3 directions of control motion simultaneously. The method, with modification, follows that by which various forces are measured on a model aircraft in a wind tunnel.

In the course of our work we are often called on to act as "guinea pigs." When necessary we use ourselves as measuring sticks and subject ourselves to whatever discomforts are required. The prone position bed development in its earlier stages was one of these. We made our bed and then we lay in it for many hours, in the beginning most uncomfortably. After we got the hang of the bed, however, this occupation displayed its advantages and we had no lack of volunteers.

FUTURE PROJECTS

Many problems lie ahead for investigation. One of the most desirable is the dynamic study of the human body mentioned previously. This will provide data for the most efficient design possible for all controls used by a pilot. Another desirable project would be a full somatotyping job on the USAF, especially now that there has been a great weeding-out program for permanent officer retention. The study of such a group in itself, and its comparison with the public as a whole,

ought to yield very useful results. Still another project of considerable utility for special purposes would be a complete contour study of a relatively small but carefully stratified series wherein all anatomical points would be located in space with respect to some zero point. This might actually be accomplished best in connection with the somatotyping job.

For the immediate future there looms a study of troop seating in cargo aircraft, and of course a continuation of the various problems connected with the prone position.

CONCLUSION

The duties of the peacetime Anthropometric Unit run the gamut from human body fact-finding through critical appraisal of engineering products to participation in original design. It is obvious that the applied anthropometrist should be familiar with a variety of engineering and mechanical techniques as well as those of physical anthropology and statistics, for they will be necessary to a full understanding of the application of his work. A competent engineer will be found a very useful addition to any anthropometric team. This new field of endeavor should prosper, because by combining the technique of making things with the technique of making things comfortable, applied anthropometry brings a definite contribution not only to military gadgetry, but also to the welfare and comfort of the populace at large.

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DIFFERENCES DUE TO AGE OF ONSET OF ADOLESCENCE.— The data emphasize the importance of a breakdown by age of onset of adolescence, in any final analysis of the problems of sexual behavior.

Not only do these earlier-developing boys have 4 years head start, and not only do they have higher rates of activity in those initial years, but they continue to have higher rates throughout the subsequent age periods. In the 15 years that lie between ages 16 and 30, the younger-developing boys have about half again as much outlet as the later-developing boys. There is still a discernible difference in the age group 31 to 35, which is 20 to 25 years after the time of onset of adolescence! Considering the multiplicity of other factors that may modify the frequencies of sexual activity, it is surprising to find such a long-time correlation with the age of onset of adolescence. In spite of their early start, and in spite of their much higher expenditure of energy in sexual activity, these early-maturing males remain more active than those who were delayed in their adolescence.

In the histories of married males, the age of the onset of adolescence proves to be as significant as in the histories of single males . . . This is astounding! . . . The effect persists throughout the lives of the married males, as far as data are available . . . 35 years after the onset of adolescence, there is still a discernible effect, which persists in spite of marriage and in spite of all of the other events that affect sexual frequencies!

. . . At least part of the long-time effects may depend upon psychologic learning and conditioning.

But it is also probable that there are physiologic bases for the differences. It is difficult to know just what these may be, for, unfortunately, there are next to no studies of physiologic capacities in relation to the age at which individuals become adolescent. There are studies of younger children, adolescents, and older adults which show correlations between their absolute ages and their physiologic performances . . . There is at least one study . . . which shows that there is some correlation between age at the onset of adolescence and blood pressures (systolic, diastolic, and pulse), the heights and weights that are ultimately attained, and some anatomic developments. Most significantly, these characters distinguish the various adolescent groups as much as 6 years before the onset of adolescence, and for at least 6 years after the beginning of adolescence . . . On the psychologic side, Terman (1925), in his study of geniuses, found that the individuals with the highest IQ's were more often those who became adolescent first. It can, therefore, be suggested that the frequency of sexual activity may, to some degree, be dependent upon a general metabolic level which the individual maintains through much of his life. — Alfred C. Kinsey, Wardell B. Pomeroy and Clyde E. Martin. Sexual behavior in the human male. W. B. Saunders Co., Philadelphia and London, 1948, xv + 804 pp. ($6.50)

ANTHROPOMETRY IN THE QUARTERMASTER CORPS

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SIX FIGURES

The advent of anthropologists into military research dates from the Civil War (Baxter, 1875; Gould, 1869). Anthropologists had been associated, prior to 1942, with the Office of The Surgeon General (Davenport and Love, '21) and had devoted their interests almost entirely to the racial and clinical aspects of anthropometry.

The entry of anthropologists into military research, in the engineering sense, furthered a new field of endeavor which has come to be called Applied Physical Anthropology. The background of researches have been previously described (Damon and Randall, '44; Randall, Damon, Benton and Patt, '46). The accompanying papers have considered in detail some of the particular applications which have been and can be made with anthropometric data. It is the purpose of this paper to give a somwhat broader picture of the Army program and to attempt to describe how anthropometry as a field of endeavor fits into the organization of military research. The application phases fall into 2 main categories. The first is, to a great extent, pure anthropometry in that it is concerned with the measurement of human beings in considerable detail. The collection of large series of detailed measurements is considered to be of primary value in that the data, when analyzed, will serve to provide a constant source of reliable information upon which further studies may be based. The second phase falls into the category of testing. In this phase,

anthropometry is highly specialized, in that small numbers of dimensions are taken and quite frequently taken on limited series of individuals which are subsequently evaluated in terms of the initial large series.

Figures 1 and 2 illustrate the data sheets which were used in the Quartermaster Corps Survey and indicate that considerable detail was utilized in developing our base references.

Form No. 1

U. S. ARMY ANTHROPOMETRIC SURVEY (MALE)

Research & Development Branch, Military Planning Division,

Office of The Quartermaster General

NAME ______________________________ (last) (first) (middle) (ASN) Date ______________

Column Punch

1 ______ SERIES NUMBER . . . .

2 ______

3 ______

4 ______ MONTHS SERVICE . . . .

5 ______ MARITAL STATUS: single[1] married[2] divorced or separated[3] widower[4]
RACE: white[5] negroid[6] mongoloid[7] other[8]

6 ______ MILITARY UNIT: AAF[12] AGF[11] ASF[10]
AAF - rated flight[1]
ground maintenance[2]
other[3]
AGF - Combat infantry[1]
ASF artillery[2]
armored[3]
airborne[4]
engineer[5]
anti-aircraft[6]
signal corps[7]
transportation[8]
other[9]

7 ______ AGE . . . .

Column Punch

8 ______ RANK: Private[1] Non-com.[2] Officer[3]

______ LOCATION: . . . .

9 ______ BIRTHPLACE SUBJECT: . . . .
State if U. S. A. Country if foreign

10 ______ BIRTHPLACE FATHER: . . . .

11 ______ BIRTHPLACE MOTHER: . . . .

12 ______ NATIONAL EXTRACTION: . . . .
(Two principal strains)

13 ______ RELIGIOUS AFFILIATION: . . . .
protestant[1] catholic[2] jewish[3] other[4]

EDUCATION: (highest school) . . . .
illiterate[5] read & write[6] grade[7] high[8]
special training (tech., bus., etc.)[9]
college[10] post-grad.[11] prof.[12]

14 ______ CIVILIAN OCCUPATION: (Prin.). . . . .

15 ______ MILITARY SPECIALTY: . . . .
(Longest time served) (MOS, if known)

Figure 1

The first of these figures shows the sociological, both civilian and military, data which were obtained. The second figure indicates the measurements taken. It will be noted that approximately half of these measurements are routine anthropometric dimensions, whereas, the other half are specialized in the sense that they compare directly with measurements ordinarily taken for clothing and other personnel equipment.

The methods of presentation of the data are highly varied and only a few examples will be shown to indicate these methods.

Figure 3 is, at first glance, one of elementary biometric method in that it showns frequency distribution of weight and

	COLUMN	PUNCH		DEC.
WEIGHT	16	.....	...	...
STATURE	17	.....	...	...
CERVICALE HEIGHT	18	.....	...	...
OUTSEAM	19	.....	...	...
INSEAM	20	.....	...	...
THIGH LENGTH	21	.....		...
LOWER LEG LENGTH	22	.....		...
ARM LENGTH	23	.....		...
BIDELTOID	24	.....		...
CHEST BREADTH	25	......		...
CHEST DEPTH	26	.....		...
TRUNK DEPTH	27	.....		...
BI-ILIAC	28	.....		...
HEAD HEIGHT	29	.....	...	...
FOOT LENGTH	30	.....	...	...
INSTEP LENGTH	31	.....	...	...
FOOT BREADTH	32	.....	...	...
HEEL BREADTH	33	.....	...	...
SITTING HEIGHT	34	.....		...
TRUNK HEIGHT	35	.....		...
PATELLA HEIGHT	36	.....		...
BUTTOCK-KNEE	37	.....		...
SHOULDER-ELBOW	38	.....		...
UPPER ARM LENGTH	39	.....		...
FOREARM-HAND LENGTH	40	.....		...
HIP BREADTH	41	.....		...
ELBOW BREADTH	42	.....		...
HEAD LENGTH	43	.....	...	...
HEAD BREADTH	44	.....	...	...
MINIMUM FRONTAL	45	.....	...	...
BIZYGOMATIC	46	.....	...	...
BIGONIAL	47	.....	...	...
FACE LENGTH	48	.....	...	...
NOSE LENGTH	49	.....		
NOSE BREADTH	50	.....		
BIOCULAR	51	.....	...	
INTEROCULAR	52	.....		
NASAL ROOT BREADTH	53	.....		
OUTER CANTHUS-OTOBASION SUP.	54	.....	...	...
HAND LENGTH	55	.....	...	
HAND BREADTH	56	.....	. .	
HEAD CIRCUMFERENCE	57	.....		. .
NECK CIRCUMFERENCE	58	.....		...
SHOULDER LENGTH	59	.....		
ARM SCYE	60	.....	...	...
CROSS BACK WIDTH	61	.....	...	
AXILLARY ARM CIRCUM.	62	.....	...	
MIDDLE UPPER ARM CIRCUM.	63	.....	...	
LOWER UPPER ARM CIRCUM.	64	.....	...	
UPPER FOREARM CIRCUM.	65	.....	...	
MIDDLE FOREARM CIRCUM.	66	.....	...	
WRIST CIRCUMFERENCE	67	.....	...	
CHEST CIRCUMFERENCE	68	.....	...	...
WAIST CIRCUMFERENCE	69	.....	...	...
HIP CIRCUMFERENCE	70	.....		...
TOTAL CROTCH LENGTH	71	.....		...
CROTCH THIGH CIRCUM.	72	.....	...	
MIDDLE THIGH CIRCUM.	73	.....	...	
LOWER THIGH CIRCUM.	74	.....	...	
UPPER LEG CIRCUM.	75	.....	...	
CALF CIRCUMFERENCE	76	.....		...
ANKLE CIRCUMFERENCE	77	.....	...	
BALL FOOT CIRCUMFERENCE	78	...	...	
VERTICAL TRUNK CIRCUM.	79	.....	...	...
SLEEVE LENGTH	80	.....		

Figure 2

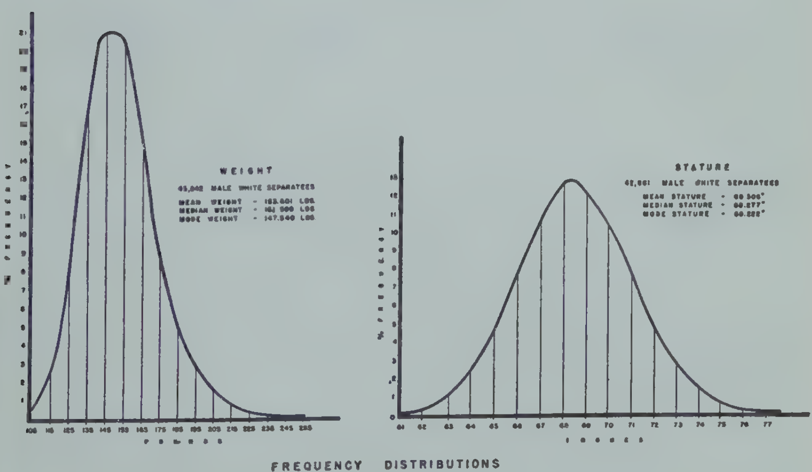

Figure 3

stature. However, these presentations are of considerable value to the consumer of anthropometric data in that they provide him with a picture of how populational groups vary in dimension. In other words, the skewed curve of weight requires one type of interpretation in a practical sense and the symmetrical stature requires another. For example, if one is concerned directly with assessing the proportions of short, regular, and long clothing categories based fundamentally upon stature, a division of the entire stature range into equal thirds will result in a nearly symmetrical balance of the proportions of these 3 categories with the short and the long being approximately equal. However, the division of girths based fundamentally upon weights will not provide this symmetrical distribution, because of the skewed distribution. To the person interested in the distributions of sizes of clothing these 2 factors are of fundamental importance.

Figure 4 shows a different type of presentation in that it attempts to indicate more fully the dynamic aspects of dimensional changes throughout a population. To the left are curves showing the relationships of 5 bodily dimensions to changes in stature. To the right is another graph showing the changes of 9 bodily dimensions related to changes in weight, with stature held constant. An example of the use of this type of presentation is as follows: Consider for a moment only the graph to the left. Again we are interested in dividing our clothing into short, regular, and long categories. Perhaps the clothing will be a single type garment such as a coverall and must involve differences in girth dimensions, as well as differences in vertical dimensions. It will be noted that the vertical dimension of cervicale height shows a good linear relation to stature as would be expected. The chest circumference and the hip circumference are almost identical but have slightly different slopes. Waist circumference is just about 5 inches below the chest circumference and the breadth across the shoulders varies about $1\frac{1}{2}$ inch with increase in stature, so these values should be incorporated into sizes of garments associated with increase in stature.

Suppose, on the other hand, referring now to the graph on the right we are considering the increase of girths associated with a single length of garment as weight increases. Outseam remains almost constant. Inseam shows a very slight decrease. Sleeve length shows a slight increase, but all the other values show varying degrees of increases, particularly waist circumference, which follows a curvilinear function. The interpretation of this type of graph then leads the designer to con-

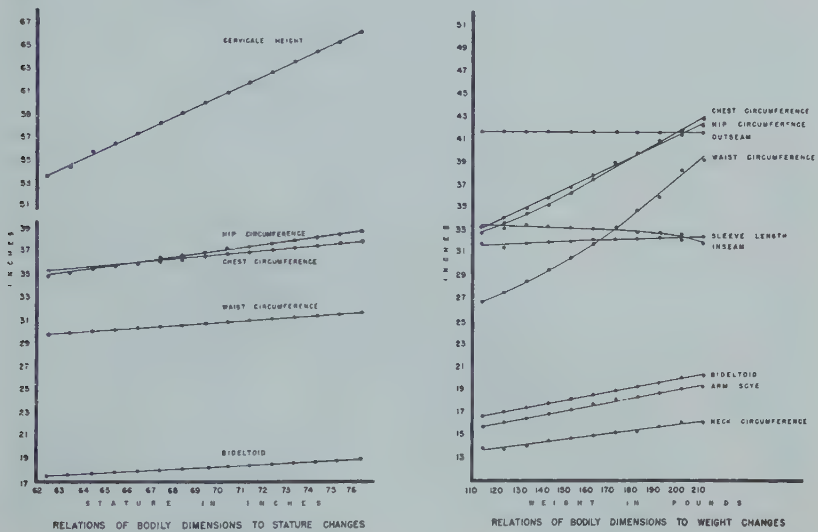

Figure 4

clusions which will aid him in grading the various girth dimensions associated with increases in weight or, in short, increases in his size evaluations.

Figure 5 is, to a great extent, a combination of the preceding 2 types of presentation. It is an effort to reduce a considerable number of variables to a single graph, in order that the designer of clothing or other engineers interested in anthropometric applications may be able to assess the adequacy of their concepts in terms of the entire male military population. The heavy black line running diagonally through the graph represents the mean weight shown to the left. Each of

the long, flat rectangles represents ± 1 standard deviation from the mean weight. The values enclosed in each of the rectangles are the mean values for 6 dimensions as noted under the legend and, also, include the standard deviation for each except for the chest-waist difference. The row of rectangles lying toward the center of the graph lists 10 dimensions associated with each 10-lb. increment of weight va-

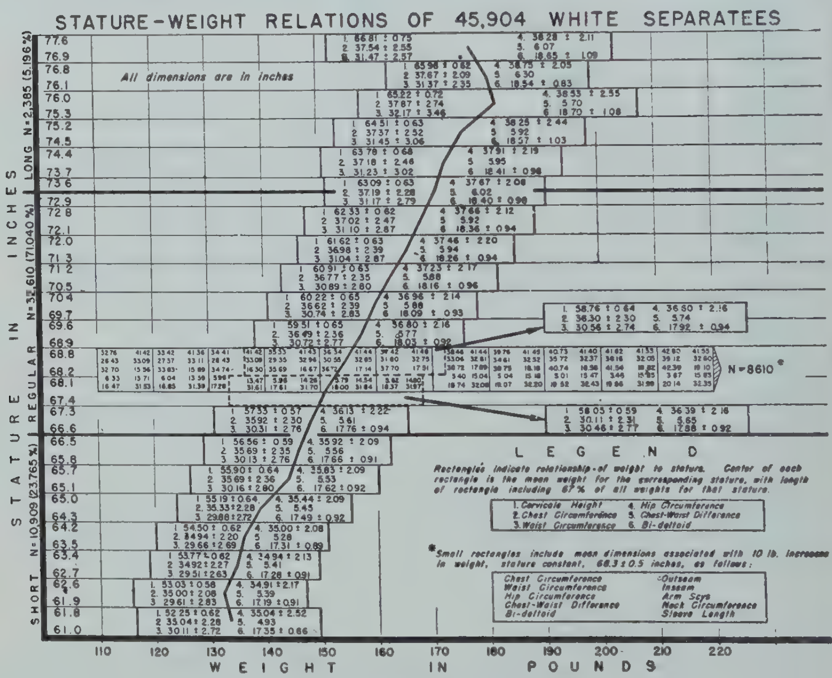

Figure 5

riation within a constant 1 inch of stature. This type of graph is of value in picturing the overall variation of the population.

Parting now from the more theoretical considerations of anthropometry in research, let us look finally at an organizational structure in which the anthropometrist may pursue his interests. Figure 6 indicates a proposed procedure which is being considered for use in the Quartermaster Corps. The development of clothing lies entirely within the realm of QM

research, but the issue of clothing falls within the storekeeping procedures. It will readily be granted that clothing, being based fundamentally upon bodily dimensions, must be handled both from the standpoint of research and from the standpoint of supply. Consequently, the field of the anthropologist then overlaps both of the Quartermaster Corps functions of research and supply. Lying to the left of the chart are the functions associated with the research phase. These

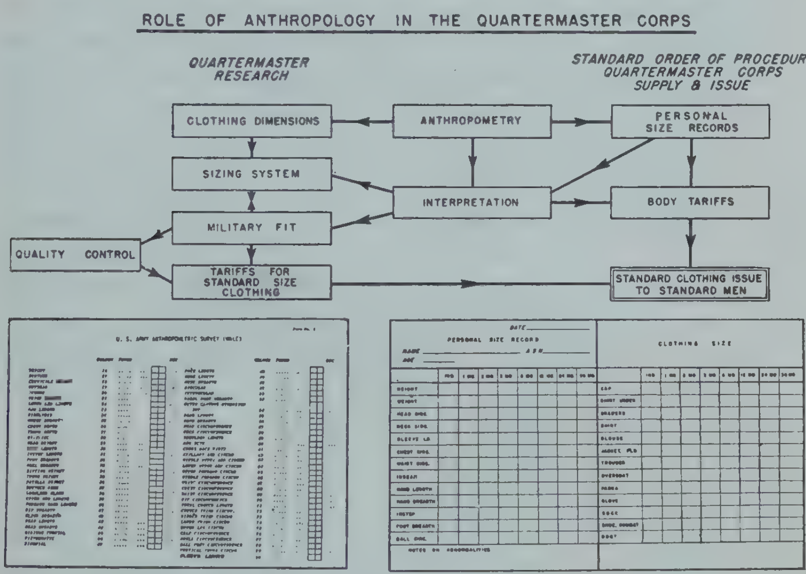

Figure 6

will include establishment of clothing dimensions, size systems, determination of military fit of clothing, establishment of quality control procedures, and, finally, the preliminary tariffs of sizes, all of these being aided to some extent by the anthropometric data collected by the anthropometrist and interpreted by the biometrician. Lying to the right is the radical departure from existing procedures. In this proposal, it is suggested that standard forms be prepared for the recording of basic anthropometric dimensions for all individuals being inducted into the Army. These forms would

be known as Personal Size Record cards and would provide constant reference data for use by both supply personnel and the anthropometrist. The collection of all these data would then be interlocked as indicated by the lines and arrows of the organization and would result in a standard order of procedure for the issue of objectively controlled sizes of clothing to known variations of body sizes within the Army or any segment of it.

The preceding paragraphs, although confined to a brief review of methods of application of anthropometry to military problems, should indicate that there is a very real place for the applied physical anthropologist, not only in military fields of endeavor, but also in all types of industry concerned in the design, development, and fabrication of equipment destined for use by the human being. This situation, only beginning to be realized by responsible personnel in industry, presents a definite challenge to physical anthropologists to produce properly trained personnel who may be equipped to continue the many ramifications of the application of physical anthropology to the comfort and well-being of their fellow men.

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REVIEWS

ANTHROPOLOGY. By [A. L.] Kroeber. Harcourt, Brace and Co., N. Y., 856 + xxxix pp., 42 line drawings and maps, 1948, ($7.50).

After a quarter of a century, Professor Kroeber, dean of American anthropologists, one of the few active survivors of his generation, has produced a complete revision of his standard textbook. He has divided it into 19 chapters, which include 333 "paragraphs" varying in length up to 10 pages. In order to present an introduction to all of anthropology, as required in introductory courses, he devotes half the space to language and culture, reserving for physical anthropology and archaeology about one fourth each. This division seems suited for use with beginners where supplementary books are not available.

Aside from this practical consideration, it allows the author to smash the artificial barriers between biology, culture, and culture-history, and to use data yielded by all 3 sets of techniques in all sections. Thus, although this review is concentrated on chapters 2–5, the physical portion, it must include some notice of the book as a whole.

From beginning to end several principles seem to have been followed: (1) To give the maximum of concrete, factual data; (2) to make the coverage of the various subjects as complete as possible in time, space, and opinion; (3) while presenting the contrasting opinions of experts in controversial subjects, to favor the majority vote, while withholding final judgment; and (4) to steer away from the methodology and terminology of any one school, while briefly describing and tentatively evaluating the systems and results of some — but not all — of them.

Although these principles seem desirable in general, 2 particular objections may be raised to their application:

1. The opinion of the majority is not always the correct one, as subsequent events sometimes show. For example, Kroeber favors the rejection of the evidence for the existence of modern-type men in the 2nd and 3rd interglacial periods in Europe. The female skull unearthed in France in 1947 under what might be called laboratory conditions definitely confirms the claim of the minority, at least for the 3rd Interglacial.

2. On pages 6 and 7 Kroeber emits the usual Boasian party-line blast against the concept of cultural evolution and levels of cultural

complexity. Unfortunately the terms of the copyright statement printed on the flyleaf prevent me from quoting his exact words. Elsewhere throughout the book he accepts this concept as a necessary part of his argument, as revealed on pp. 58, 70, 71, 191, 192, and 203, to mention only those references found in the chapters on physical anthropology. In chapter 7, paragraphs 127 and 128, he discusses this problem specifically, and proposes a series of 3 channels in which he finds progressive, coordinated cultural changes in human societies, and he ends this section with a caution that quantitative increases in cultural complexity (the existence of which he admits) do not imply increases in wisdom or happiness. Later, chapters 16–18 constitute a record of progressive cultural change, largely *à la* Gordon Childe. All of this seems strangely out of tune with his pronouncement on pp. 6 and 7.

Returning to the 4 chapters on physical anthropology, we discover an admirable integration between anatomy, physiology, and behavior. Kroeber starts with single-celled animals and passes through the phyla in order of increasing complexity. His attention is always devoted to essentials, such as the development and integration of digestive tracts, limbs, and nervous systems, and the importance of bilateral symmetry in mobile forms. He discusses the factor of absolute size, in the manner of d'Arcy Thompson, something which most anthropologists forget or ignore. He compares the length of the learning period in man with that of other animals, and emphasizes the importance of play. Turning to primates, he describes the physiques and behavior patterns of the 3 largest apes, omitting the gibbon.

Reviewing the evidence of fossil apes, he reproduces the family trees proposed by Hooton, Gregory, Keith, and Broom. He concludes tentatively that man is closer kin to gorilla and chimpanzee than either of these 2 apes is to the orang, with the gibbon left far to the rear. This is one of the few places where Kroeber, to use a simian simile, puts himself out on a limb. The work of Straus and others on the possible relations between man and "other ranks" of primates is not mentioned.

He next reviews the field of ape psychology, with special emphasis on invention and problem solution, construction and destruction, and the aesthetic impulse, as anticipations of cultural behavior, but he says little about primate social organization and nothing about the inimitable work of Carpenter. Then he points out the importance of the increase in the cerebral cortex in man as the principal cause of the beginning of culture, which he characterizes as a gradual accumulation, starting at some critical point in the past, which marked the threshold between pre-man and man.

Emphasizing also the unique character of the human posture, he shows that beside man only the domestic animals have been able to preserve certain mutations which in wild forms might disappear through unfavorable selection. These include glabrousness without skin thickening, curly hair, pigment aberrations such as partial albinism, steatopygia, and lip eversion. This casts on certain primary racial variations a light which will be new to most students, and most helpful.

So far, aside from the neglect of the gibbon and pronograde monkeys, all is clear. When, however, Kroeber discusses fossil man, he enters an arena from which no textbook writer could hope to emerge unscathed. He divides existing remains into 3 grades or levels: Protoanthropic, Palaenthropic, and Neanthropic. Pithecanthropus, Sinanthropus, and Africanthropus take up most of the space on the bottom shelf. Neanderthal, Palestine Man, Rhodesian, and Solo occupy the second, while Cro-Magnon, Afalou, and the South African crania from Florisbad to Boskop rest on the top. Full mention is made of certain oft-neglected remains, such as Oldoway, Talgai, and Keilor. However, he places in the doubtful category all the skulls of Western Europe and East Africa which upset the evolutionary schemes of the 2 late experts, Hrdlička and Weidenreich, with the result referred to earlier in this review.

In the chapter on living races he describes some of the most popular criteria, and then delineates what he calls the 3 main stocks, Caucasian, Mongoloid, and Negroid, with an added section devoted to "doubtfuls," in which he places the Australian Aborigines, Veddoids, Ainu, and Polynesians. He reviews the distributions of special traits in Europe, using simplified versions of my maps on hair and eye color and the cephalic index, plus a map on the facial index attributed to Struck.

He reviews the classifications of Deniker, Huxley, Boas, Czekanowski, von Eickstedt, and Hooton, in some detail. On page 151 in a footnote he attributes to me a theory or theories on the origins of Dinaric and Alpine types, which I do not fully understand. His treatment of the above mentioned systems of classification, which he quotes at length, is critical, and he, in my opinion, wisely questions the insistence of some of these authors on genetic continuity whenever similar traits are found in areas widely separated in space and lacking in archaeological or historical continuity.

His discussion of the blood groups is adequate except for an apparent failure to understand all of the implications of the recently discovered subdivisions of type A, especially the proof that parallel mutations can produce phenotypically similar results, which applies to hair form, skin color, and many other features which have puzzled taxonomists for generations. He could have used this to effect in

bolstering his position stated in the last sentence of the preceding paragraph.

Section 73, on the effects of self-domestication in man, is one of the most valuable passages in the book; here he restates and exemplifies the data previously mentioned about curly hair, depigmentation, overpigmentation, excessive fat deposits, and jaw reduction in domestic animals and man. Here he touches on the causation of racial differences — mutation and selection under pre-cultural and early cultural conditions. One would like to see more of this, at the expense of the recapitulation of other men's opinions. His discussion of recent somatic changes in response to culturally induced stimuli might also have been extended.

In sections 76–79 Kroeber sets up an alley-full of straw men and knocks them down, one at a time. These are the hologenesis theory of Rosa and Montandon, Keith's endocrine speculation, the fine-coarse theory of Baelz and Legendre, and constitutional theories from Kretschmer to Sheldon. None of these, however, is bowled quite out of the alley. Each is left lying in such a position that it may be set up again if a new pin-boy so chooses. Here one is tempted to question not so much Kroeber's criticisms as the amount of space he has given each of them. To polish off chapter 4 he restates, briefly and clearly, the old but necessary warning against confusing race, nationality, and language.

In chapter 5 he tackles fairly, factually, and without fear, what is the touchiest subject not only in anthropology but also in the domestic politics of the United States in the year 1948: the question of racial differences in mental capacities, however defined. While most anthropologists either shun it as they would leprosy, or make soothing noises toward the prevailing doctrine, Kroeber rolls up his sleeves and pitches in. He first reviews the evolutionary status of the different races, leaving the verdict open. Here he falls into the customary pitfall of confusion, by failing to distinguish between 2 sets of characters: historically progressive evolutionary changes in brain size, skull thickness, jaw thickness, and tooth size, through which all human strains have been passing at different rates; and those special adaptations to extremes of heat and cold, fog and sunshine, which some but not all of our ancestors acquired during the long millenia of the Pleistocene. His review of the data on the physiology, pathology, and sensory acuity of races is pertinent and competent.

In opening the subject of inter-racial comparisons in intelligence tests he repeats the World War I statistics, as well as Garth's American Indian material and the Jamaican evidence of Davenport and Steggerda. Unlike most authors who have redigested this material, Kroeber admits the theoretical importance of hybridization, reveal-

ing a basic fallacy of the World War I test data, in which all persons not socially rated as White were therefore called Negro. This, of course, placed many "White" genes in the Negro camp, and vice versa. Everyone admits that by showing cultural differences these tests obscure the racial factor, but few have also drawn attention to this second source of error.

Kroeber's excursion into the cultural records of races is solid, but fails to admit the role of environmental opportunity, a subject reserved for a later chapter. In his review of Galton's work on the inheritance of genius he points out that genius is hard to recognize in a primitive degree of civilization (sic!). He has left the door open for future discoveries of racial differences in behavioral capacity, a subject in which it may be safer for us to remain in ignorance until we have grown more civilized.

The book is written in a youthful and vigorous style, with apt similes and a knack for choosing the dramatic phrase. One wishes that he had given it a proper bibliography, instead of referring to his sources by the author's names only, in many instances. But that is a technical defect only. The book is full of wisdom, as is its author, and even in the face of a spate of newly published competitors, should have success.

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HUMAN ANCESTRY: FROM A GENETICAL POINT OF VIEW. By R. RUGGLES GATES. Harvard University Press, Cambridge, Mass., xvi + 422 pp., map, 8 text figures, 27 plates, 23 tables, index, 1948. ($7.50)

According to the preface, this book is a study of the origin and history of the races of mankind, based on the evolutionary background. Although Professor Gates is a botanist, the choice of the subtitle, "from a genetical point of view," does not seem too surprising in view of Gates's long-standing interest in human genetics and considering his many contributions to the subject. However, in looking through the volume one cannot help gaining the impression that there is hardly a single reliable genetic statement in the whole book. The book, in fact, consists of certain preliminary chapters dealing with the "principle" of parallel evolution, the evolution of mammals, and the evolution of the hominidae, and then proceeds to a very detailed, and rather difficult-to-read, description of certain skeletal remains which are thought by the author to have some bearing on the ancestry of man. The writing is inclusive rather than critical, and in fact in some

places the amount of detail is almost incredible. We are informed, referring to one of the Grimaldi caves, that 2 children's skeletons, nearly complete, were discovered there in 1874 and 1875 at a depth of 2.7 meters, but that the skulls were broken into fragments and are of little use. If the skulls were of little use then, a recital at the present time of the circumstances of their being found can hardly be of any greater use. Great detail as to the sedimentary and stratigraphic and other characteristics of the material in which human remains have been found is given. All this makes the reading difficult, because there seems to have been little if any attempt to collect and correlate the facts which are important to the reader, and leave out those which, although perhaps of importance to specialists in the field, will not mean much to the general reader.

A comparison of this book with some of Professor Gates' earlier papers reveals what seems to the reviewer the fundamental defect. Professor Gates is a "racist," that is, he is one of those people, who, like the Nazis of the Germany of 1933–1945, believes in the superiority of certain races and the inferiority of others. We have had previous expositions of this point of view in the writings of Houston S. Chamberlain, Madison Grant, Adolf Hitler, *et al.* But Professor Gates is not content merely to be a "racist," he is actually a "superracist," in fact he is a "speciest," for he has decided that mankind, instead of being separately divided into races, should be divided into exactly 5 human species; *Homo australicus, Homo capensis, Homo africanus, Homo mongoloideus,* and *Homo caucasicus.* In spite of the interfertility which is known to exist between these different races, or as Professor Gates would prefer to say, species, he regards them as valid species and suggests that the old fashioned name of *Homo sapiens* is to be discarded or at the most to be permitted to be retained as "a super species, including all living species, if desired."

Even if the genetical point of view were not beginning again to gain ground among physical anthropologists one could not ignore a book such as this. There may be a number of students, for instance, who will not know that practically all physical anthropologists (and certainly all practicing geneticists) will completely disallow nearly all of the claims made in this book, especially the idea that mankind is to be separated into 5 separate species. Therefore it seems necessary to call attention to the fact that the views of Professor Gates as expressed in this book are probably unique and that it is very doubtful if any anthropologist or any geneticist shares his point of view to any considerable extent.

It is true that one of the leaders of American anthropology, Prof. E. A. Hooton, wrote a foreword for the book, but on inspection it will be seen that this is a very cautious foreword indeed, and it looks

as if Professor Hooton does not mean to indorse to any extent the views of Professor Gates.

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HUMAN ANCESTRY: FROM A GENETICAL POINT OF VIEW. By R. Ruggles Gates. Harvard University Press, Cambridge, Mass., xvi + 422 pp., map, 8 text figures, 27 plates, 23 tables, index, 1948. ($7.50)

The psychoanalysts have some very pat answers as to why human beings have such an intense preoccupation with the problem of parentage, filiation and ancestry. Be these as they may, the book here reviewed addresses itself to the broad problem of the evolution of the Hominidae and the ancestral lines which can be picked out of the evidence currently available to us. I have used the words "picked out" deliberately. Anyone who has involved himself with establishing a family geneaology knows that he must use certain guiding principles to distinguish one line from among the welter of collateral lines. The surname is the major clue in these current investigations. But the student of human ancestry has no such simple device. He gives names to his specimens after due consideration as to whether their bony or dental morphology is like or unlike other primates, extinct or living. Always is it implicit, not always is it explicit, that the palaeoanthropologist is weighting this characteristic more and another less. The postulates involved are sometimes formulated, sometimes not. But the result is at best a reasoned estimate of the probabilities of the relationships of one primate to another, and in this respect a family tree of the Hominidae is very different from the family tree of the Plantagenets.

Gates brings the postulates of genetics to this field and the results are interesting if, in my opinion, not very conclusive. Some of his worst difficulties arise from using evidence presented by workers innocent of the basic principles of Mendelism. But of this more later.

The first general criticism of the book as a whole can be put in the form of a question. To what audience is it presented? It begins with a chapter on the "Principle of Parallel Evolution," which is followed by one on the "Evolution of the Mammals." The non-specialist reader will find these pages hard and heavy going and to some extent meaningless; the specialist is not going to be happy with Gates' over-condensed recapitulation. Chapter four, "Evolution of the Hominidae," sets the stage for a series of chapters which describe the local

evolution of the Hominidae in their modern forms in southeast Asia and Australia, Africa, Europe, the New World and lastly Oceania. Gates has read omnivorously but how wisely is another question. The literature of palaeo-anthropology and of racial anthropology is voluminous, a lot of it is contradictory, most of it really is not very good. Gates has summarized a great part of it and the result to the non-specialist reader is certain to be bewildering. One consequence of this is that I am unable to see how it can be used profitably with any but the most advanced students. Let me say at this point that the foregoing criticism has nothing to do with Gates being a geneticist and a botanist. The task which the author set himself was a Herculean one. I think that the incomplete success in discharging this task can be laid to lack of boldness in discarding or ignoring some of both the older and the modern literature in the field.

The ideas of the importance of parallelism as an evolutionary "principle" and of the specific distinctions between the modern races of man are already familiar to Gates' readers. As to the first, it seems to me he is over-laboring the point. Not many modern writers with any fundamental knowledge of fossil primates will deny parallel development of an evolutionary character. The usual crux is how many lines they will admit and at what point in time the diverging group began its development. The time element is of major importance and Gates' arguments suffer, as do those of the rest of us, from the unfortunate lack of precise dating for a number of morphologically significant fossils: Piltdown, Africanthropus, Rhodesian, the Australopithecinae, to name a few. It has always been true — and it has been crystal clear for 25 years — that with fossil hominids morphology as a guide to the antiquity of the specimen gives one moderate probabilities at best. It is with this conviction in mind that I view Gates' discussion of the local evolution of human types in Africa where so many of the sub-fossil and fossil hominid forms are insecurely dated. It seems to me that the problem is not to show that modern Africans had more primitive humans as ancestors but to demonstrate who these ancestors were. When the context for Africanthropus or Rhodesian is blurred, or contradictory, one cannot circumvent this limitation by any method common to the sciences. One can assign these timeless fossils to "stages" and frankly admit one is working with an abstraction. Mostly none of us are really candid about this matter of "family trees" — they all represent a quite high level of abstraction; but we fool ourselves, and our audiences, by using a phrase that in another context does have a very concrete meaning. With this idea in mind I examined Gates' diagrams on page 56, Scheme of Higher Primate Evolution, and on page 161, Scheme of Human Phylogeny. The florid symbolism is too precious

for my taste. It seems also to betray a lack of awareness of the realities, of the real meaning of such constructs. As to the intra-Primate relationships which these diagrams express, the second is devoid of any explicit indications of the time factor, and in point after point I would read the evidence quite differently from the way Gates does.

The second of the main ideas which pervades the book is Gates' belief that the systematics of the Hominidea is wrongly expressed by current terminology. His conviction is that the criterion of sterility, or the lack of it, between the human groups which most of us speak of as major races or stocks, has been overworked and that we are blindly following an 18th century Linnaean dogma in calling all living hominids by the same species name. He points out that among the fossil mammalia the paleontologists derive one genus from another genus without the least embarrassment. My commentary on the whole matter is that Gates is really fighting the battle of ''natural'' as against ''artificial'' classifications. All classifications are artificial; what we achieve with some is a high degree of probability that we are expressing reality; with others the degree of probability is disappointingly low. This state of affairs will continue, furthermore, because it seems unlikely that one master set of criteria will separate ''good'' species from ''bad'' species. To imply that genic-pattern is a sure-fire solution is begging the question by redefining it. Some of Gates' strictures on our lack of awareness that taxonomy may be affected by other parts of our culture, our political or social ideologies, are well put. I am yet to be convinced that he has a better hypothesis than the generally current one that the living hominids represent a single polymorphic species. Differences in gene pattern can range from 1 to n genes. How great a difference is needed to constitute a valid species difference? Gates wisely does not say.

The difficulties alluded to earlier, into which Gates plunges, come out quite clearly in chapter 5, Head Shapes and Their Inheritance. Internal evidence (first sentence, p. 144) points to this chapter having been an insertion. It does not fit very well and I am unable to see that it contributes greatly to the main theme of the book — human evolution past and present. Gates makes much of Dart's work on the crania of Egypt. Dart, in my view, has made the genetic assumption that particular values of the cephalic index and of the length-height index are linked, and that they mean the same thing genetically whenever you find them. Thus dolicocephaly and hypsicephaly mean Nordic, dolicocephaly and chamaecephaly mean Boskop, brachycephaly and hypsicephaly mean Armenoid. This is the same basic postulate which underlies Dixon's work and of this Gates is quite critical. Elsewhere he emphasizes the importance of random segrega-

tion, of the complexities of the known inheritance of head-form and of head-shape and yet here he warmly accepts Dart's results. My scepticism is not because I doubt that there may be genetic linkages between these traits but I would like to have it demonstrated with some good material based on known genealogies.

Most of the illustrations are a puzzle. It is not clear to me why many of them were included, and the Harvard Press did not do a good job in reproducing the plates. Gates' system of chapter bibliographies is one I wish he would abandon. References in the text can be found, but not always in the chapter bibliography where one would expect to find them, and there is a considerable amount of duplication which a terminal bibliography would eliminate. Afalou is consistently given an extra "l."

Despite my view that Gates' total contribution is a mediocre one to the problem of human evolution and its patterns, I am and will be interested and stimulated by his labors. I certainly would buy his book. He has pointed up some of the troubles which beset anyone studying primate relationships. If part of this he did unconsciously, nonetheless he deserves credit for it. A thoroughly critical reappraisal of the evidence is still in the future apparently.

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THE INTERNATIONAL CONGRESS OF AMERICANISTS will hold its 29th session in New York City the second week in September, 1949, under the sponsorship of the Viking Fund, Incorporated, New York City. The Committee on Organization consists of Froelich Rainey (Chairman), A. V. Kidder (Secretary), Wendell Bennett, John M. Cooper, A. L. Kroeber, and Ralph Linton. Details of the program are now being worked out and will be announced at a later date. Enquiries may be addressed to the International Congress of Americanists, 14 East 71st Street, New York City.

THE ADOLESCENT MANDIBLE OF AUSTRALOPITHECUS PROMETHEUS

RAYMOND A. DART
University of the Witwatersrand, Johannesburg, South Africa

SIX FIGURES

INTRODUCTION

Mr. James Kitching's discovery in September, 1947, of the occiput of the new man-ape species *Australopithecus prometheus* from Makapansgat near Potgietersrust in the Central Transvaal was reported by me in a recent number of this journal (n.s., vol. 6, no. 3, pp. 259–283). This year Mr. A. R. Hughes, Laboratory Assistant in the Department of Anatomy, joined the working party of the Bernard Price Foundation for Palaeontological Research in the Makapansgat Valley at the beginning of July, to initiate a more systematic analysis of the limeworks dump site. It was here that the occiput of *Australopithecus prometheus* and many other fossil remains had been recovered from the grey breccia layer. On Tuesday, July 27, 1948, he was working in the dump about 20 feet away from where the occiput had been found when he displaced a piece of the grey bone-bearing breccia, which rolled down to Mr. Scheepers Kitching, who was assisting him at the time. Removal of adjacent breccia soon revealed to these ardent collectors a "chinless" mandibular symphysis. The concluding days of Mr. Hughes' vacation leave were devoted by him and Messrs. James and Scheepers Kitching, working in relays, to isolating from the block, the virtually perfect body and dentition of an adolescent australopithecine mandible (see plates and fig. 1), which had been fractured before fossilization.

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I am referring this mandible, because of its association, to the same species as was represented by the occiput, viz.: *Australopithecus*. The occiput demonstrated that the Makapansgat *Australopithecus* was comparable in brain size (650 cm³) to *Paranthropus robustus* Broom, from Kromdraai; the concomitant fossils showed its contemporaneity with the small-brained (450 cm³ approx.) *Plesianthropus*

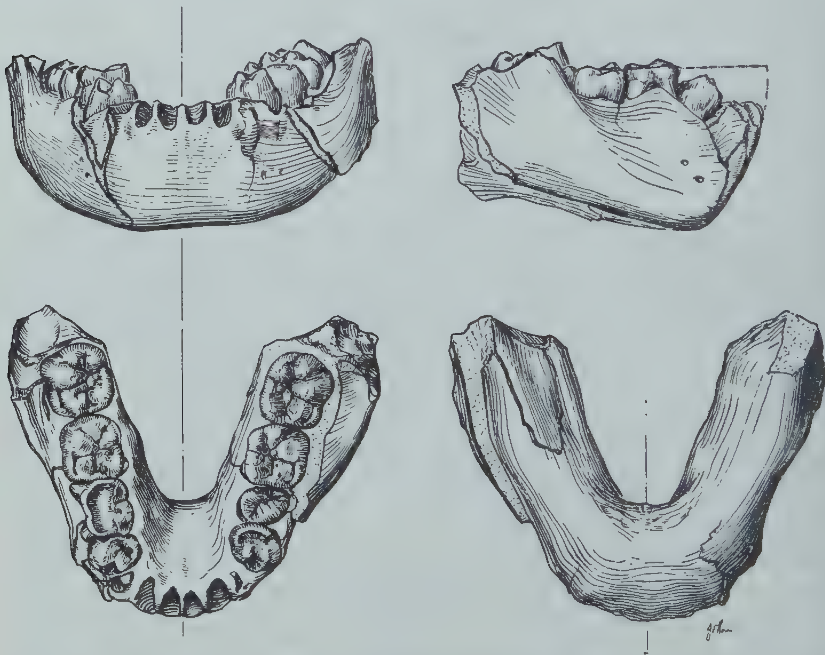

Fig. 1 Adolescent mandible of *Australopithecus prometheus* as seen from the anterior, lateral, superior and inferior aspects, respectively. (⅗ nat. size.)

transvaalensis Broom, from Sterkfontein, which is presumed to be geologically older than *Paranthropus*. The "Inca-bone" character of the expanded occipital plane and the horizontally displaced nuchal plane of the occipital bone in *A. prometheus* showed it to be more closely allied with the human stock than either of its other known adult relatives, *Plesianthropus* and *Paranthropus*. That opinion is now corroborated by the mandible and teeth.

Age of the specimen

It is possible, though of course highly improbable, that this adolescent mandible belonged to the same individual as was represented by the occiput. The partial closure of the cranial sutures exhibited by the Makapansgat occiput is compatible with that possibility, if the cranial sutures in *Australopithecus*, as in anthropoids and in *Pithecanthropus*, fused at an earlier age than in *Sinanthropus*.

Whether the two specimens came from the same individual or not, the mandible corroborates the evidence of the occiput and other australopithecine remains that the living creature (or creatures) to which they belonged met their death by manually applied violence. The fractures exhibited by the mandible show that the violence, which probably occurred in fatal combat, was a localized crushing impact received by the face slightly to the left of the midline in the incisor region, and administered presumably by a bludgeon. The result of that decisive blow, as far as this mandible is concerned, was that the 4 permanent incisors (and perhaps the left second deciduous molar) were sprung from their sockets and the bone was shattered. Seen from the front the mandible displays abrasion and fine cracking over the upper half of the left canine region (or canine alveolar jugum) together with 2 diagonally-situated fractures that course downwards and leftwards from the right first premolar and the left second premolar sockets respectively (see fig. 1). Seen from above and below it is apparent that the posterior and rightward direction of the force applied was so great as to split the left half of the massive body longitudinally in several places. Thus most of the lateral part of the left side of the body behind the second premolar socket (and therewith apparently the left ramus behind the second permanent molar) became separated from the remainder of the bone. But the slight degree of displacement of the fractured parts, their hinged relationship to one another and the absence of any evidence of healing at the fractured margins, show collectively that death was vir-

tually instantaneous and that the fractured parts of the bone were held during desiccation in approximate apposition by some of the attached surrounding tissues until they became embedded in the limestone matrix.

I have dealt in detail with these stigmata of deftly directed force to show that this youth probably met his fate at the hands of a kinsman more expert than himself in the accurate application of directed implements. As no purposely fashioned implements have as yet been discovered in the deposit, the implement was probably an ungulate long bone of the type discussed in my earlier paper (Dart, '48) or an unworked stone.

The dentition, which lacks only the permanent incisors, shows an adolescent mandible with an eruptional pattern of the permanent dentition differing from that generally characteristic of modern man. In man the first and second premolars generally erupt in the 9th and 10th years of life, respectively, but can erupt during the 11th or 12th year. In any event the premolars erupt before the second molars (or 12-year-old teeth) appear. In *Australopithecus prometheus* the second permanent molars are both fully erupted, and yet, although the first premolar on the left side has erupted, the one on the right is only half erupted and the second premolars have not as yet emerged from their eruption canals. The well-worn second milk molar is still in position on the right side; while, on the left side, the crown of the second premolar is partially exposed as it lies in its eruption canal. This pattern in which the second molars erupt before the premolars (that ordinarily erupt in the 9th and 10th years) is found in the anthropoids and lower primates; but it does also occur in some human races such as the Bushman (Drennan, '32), Neanderthal Man, and even the race represented by the sapient human youth from Grimaldi.

The macaque monkey starts to erupt its permanent dentition at the age of one and one-half years, the chimpanzee at twice that age, i.e., at the end of the third year, and man at twice the latter age, viz.: 6 years. On the average the permanent

dentition of the macaque is completed at 7½ years, that of the chimpanzee at 11 years, and that of man at 20 years (Schultz, '35).

The advanced state of wear attained by the millk dentition prior to the eruption of the first permanent molars in the Taungs infant indicated that dental development in the australopithecine group was delayed during an extended or retarded infancy more comparable with that characteristic of mankind (Le Gros Clark, '47; Dart, '48). Drennan has said ('32): "A gorilla of four years has the dentition of child of six, at the age of six a gorilla has the dentition of a twelve year old adolescent, and at seven or eight a gorilla is practically mature. That is to say human infancy is prolonged over that of the anthropoid, human childhood is still further prolonged and human adolescence is relative to that of the anthropoid, the most prolonged of the three growth periods."

In the Makapansgat mandible the second milk molar is still retained and has undergone such further wear that the cusps are almost entirely obliterated although the second permanent molars have erupted and first permanent premolars have almost erupted. The first permanent molars also display distinct attrition of the three lateral (buccal) cusps. In the interim the jaw has lengthened, widened and become much more massive (vide plate 2). Thus the Makapansgat adolescent reinforces the evidence of a delayed infancy afforded by the Taungs infant by indicating that dental development in the australopithecine group was still further prolonged over an extended or retarded childhood, such as is characteristic of mankind. Hence its actual age was probably closer to that of the 12-year-old human adolescent than to that of the 6½-year-old chimpanzee or gorilla youth.

The dentition in general

From the following comparative table of measurements (in mm) it is clear that *Australopithecus promctheus* diverges

appreciably from the previously known australopithecine forms.

	PLESIANTHROPUS		PARANTHROPUS		A. PROMETHEUS	
	A.–P.	Tr.	A.–P.	Tr.	A.–P.	Tr.
First lower premolars	13.0	?	10.2	12.8	11.5	13.0
Second lower premolars	10.3	12.0	11.8	13.5	?	?
First lower molar	13.5	11.5	14.4	13.2	14.5	14
Second lower molar	17.5	15.5	15.6	14.6	16.5	15
Second lower milk molar	11.0	9.0	12.0	9.7	12.5	10.5

The teeth are also on the whole more broad and cubical in build in *A. prometheus.* In size the first molar of *A. prometheus* is most closely approached by *A. africanus* (14.5 $\times$ 13.3 mm) but the crowns differ considerably from those of the Taungs specimen in presenting no trace whatever of a 6th cuspule (thus leaving a greatly enlarged 5th cusp almost centrally placed), and in exhibiting a well-marked cingular furrow and cuspule on each of the antero-external molar cusps (vide plate 2 and figs.).

Such a dentition demands an adult mandible more robust, if not actually more massive than that of *Paranthropus robustus* Broom. If the height (24 mm) of the mandible be compared with its width (21 mm) in the vicinity of the first permanent molar, we discover a robusticity index of 87.5 for this juvenile as compared with 70.6 for the adult *Paranthropus,* in a cast of whose mandible the corresponding measurements are 34 $\times$ 24 mm. The jaw of Heidelberg Man is not more than 20 mm in diameter at the second molar tooth, and is also 34 mm high in this region (see fig. 2).

In some respects the most valuable evidence afforded by the new jaw comes from its complete symphyseal region, which exhibits no trace whatever of a simian shelf or a genial pit (see fig. 2) on the concavo-convex or voluted lingual aspect, but a sloping and somewhat convex contour anteriorly and thus reminiscent of the Mauer jaw (see fig. 2) and of *A. africanus* (see figs. 2 and 3). Its height (30 mm) is less than twice

its thickness (18 mm). The Mauer jaw had the same thickness (18 mm). There is no chin but there is a distinct subincisival inverted triangular area of flattening on the anterior aspect (figs. 1 and 2) of the mandible. The base of the triangle is formed by the alveolar margin of the incisor sockets, its sides are limited by the thickening of the alveolar juga of the canines, the juga meeting below at the apex formed by a transverse symphyseal ridge. This transverse ridge is

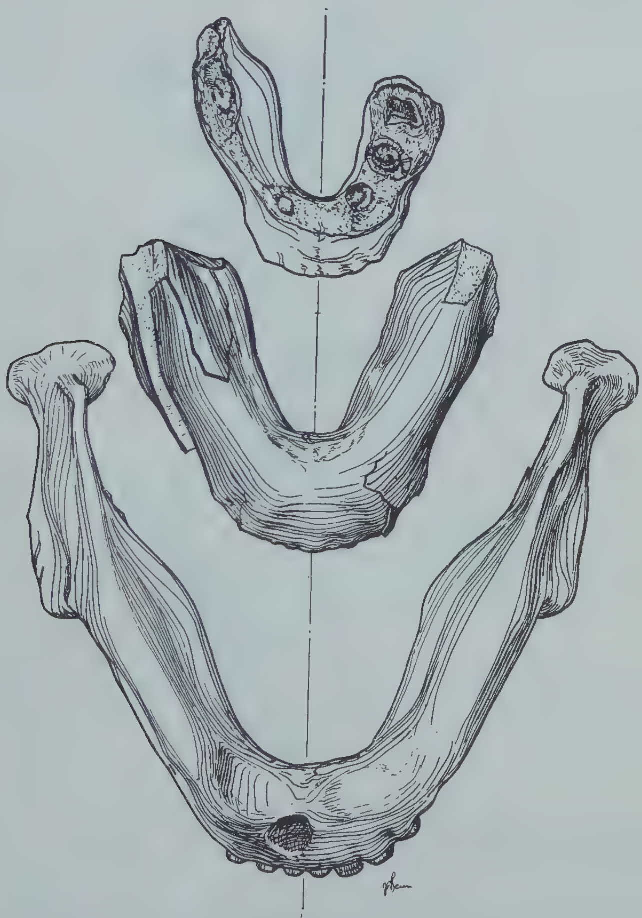

Fig. 2 Comparative drawings from the inferior aspect of the mandibles of *Australopithecus africanus* (top), *Australopithecus prometheus* (middle), and *Homo heidelbergensis* (bottom). (⅗ nat. size.)

not sharply demarcated from either the juga or the anterior prolongations of the lateral mandibular prominences, with which the juga fuse. The "incisura submentalis" is about 1 mm deep and 15 mm broad, so a true incisura, such as occurs in Heidelberg and Neanderthal Man and even in *Sinanthropus*,

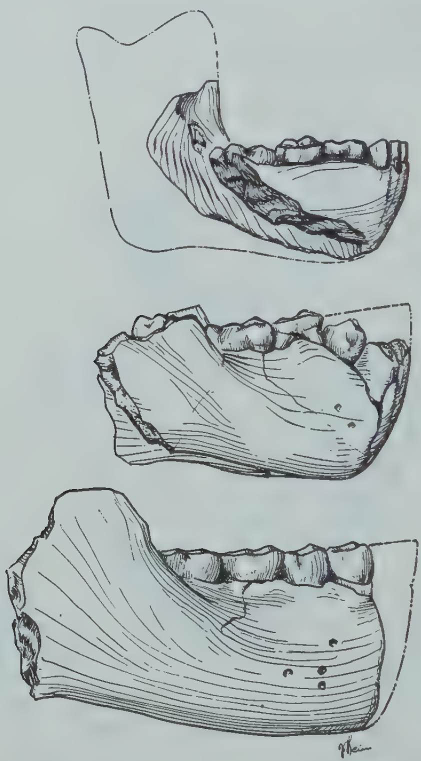

Fig. 3 Comparative drawings from the lateral aspect of the mandibles of *Australopithecus africanus* (top), *Australopithecus prometheus* (middle), and *Paranthropus robustus* (bottom). ($\frac{3}{5}$ nat. size.)

can scarcely be said to exist, the torus lateralis superior being continued around the "chin region" into its fellow of the opposite side. There is thus also no true *tuber symphyseos*, the inverted triangular area of flattening displaying merely a slight linear vertical ridging between the two central incisors (see fig. 1, anterior view).

A somewhat similar but shorter linear vertical ridge appears on the posterior symphyseal aspect in the situation where the genial musculature took origin from the inferior aspect of the transverse mandibular torus (see fig. 1). There is no evidence whatever of a genioglossal fossa on the lower and convex portion of the posterior aspect of the symphysis nor of a second or inferior (transverse) mandibular torus

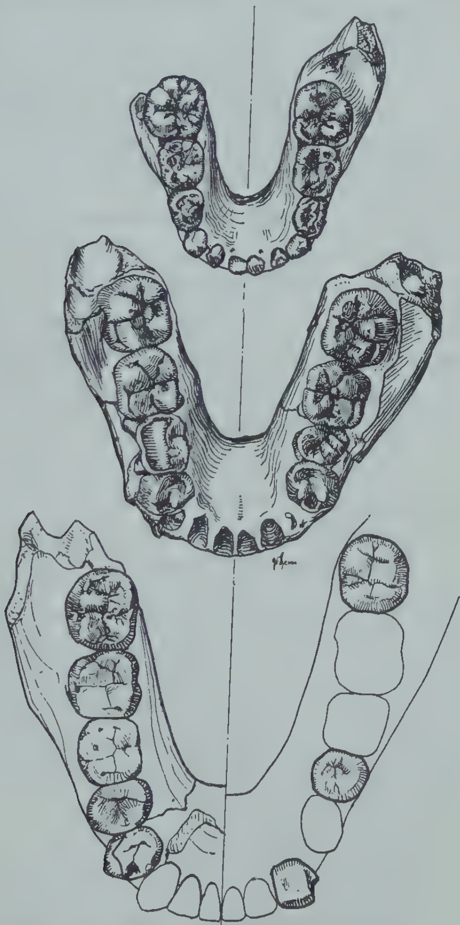

Fig. 4 Comparative drawings from the superior aspect of the mandibles of *Australopithecus africanus* (top), *Australopithecus prometheus* (middle), *Paranthropus* (bottom left) and *Plesianthropus* (bottom right). The last two are based upon Broom's reconstruction. ($\frac{2}{3}$ nat. size.)

(or basal plate) such as is found in living anthropoids. From the alveolar border above the inner scalloped surface of the symphysis first runs downwards and backwards on a slightly concave inclined plane (vide figs. 1, 2, and 4) for the distance of approximately a centimeter; then it passes over the convexity of the inner mandibular arch (*arcus intermedius* of Virchow) and retains this smooth and uniform posteriorly-convex conformation until it sweeps forward to meet the inferior border of the mandible. In consequence the almost biconvex outline presented by a sagittal section through the symphysis is dissimilar (especially posteriorly), from any anthropoid or primitive adult human jaw (such as the Heidelberg, Neanderthal and most of the Sinanthropus specimens); it approximates more closely the contour exhibited by the Gibraltar child and the modern North Chinese child, both of which are only at the milk dentitional stage of development, as figured by Weidenreich ('36, fig. 72, p. 185). This absence of a genial depression in the Makapansgat adolescent is the more surprising since the infantile Taungs mandible certainly exhibits a definite, though shallow, pit below the inner mandibular arch.

On the rounded inferior aspect of this posterior convexity on either side of the midline the faint semi-crescentic outlines of the digastric impressions appear just behind the inferior border of the mandible (see figs. 1 and 2). Comparison from the inferior aspect of this mandible with that of the Taungs infant on the one side and that of Heidelberg Man on the other side reveals the broad similarity in their massiveness and general dimensions. At a point 20 mm behind the posterior margin of the mandible the distance between the jaws (i.e., the base of the mandibular arch) is 18 mm in the infant *A. africanus*, 28 mm in the adolescent *A. prometheus* and 40 mm in the adult *H. heidelbergensis* (see fig. 2). The additional widening of the arch that had to take place in this vicinity to form a jaw such as that of Heidelberg Man is only slightly more than actually occurs between these two stages of growth in the australopithecine mandible. But it is clear,

if we accept Broom's reconstructions (see fig. 4), that very little further actual widening occurred to produce the adult australopithecine jaw after the second molars and the premolars had erupted.

The comparative growth series of mandibles now available (see fig. 4) reveals a remarkable stage of intermediacy between anthropoids and man in respect of forward facial growth during australopithecine ontogeny. As Weidenreich so effectively demonstrated in his study of the mandibles of *Sinanthropus pekinensis* ('36, pp. 105–112) the process of widening the jaws during ontogeny causes the anterior arch in the human mandible to be shortened, whereas this "pre-postlacteon" portion of the mandible[1] is lengthened in anthropoids during the growth that takes place subsequent to the eruption of the milk dentition. In this respect *Sinanthropus* simulates modern man though the reduction in length is not quite so great as in modern man. In the Australopithecus series exhibited here (figs. 3 and 4) the "pre-postlacteon" portion of the mandibular arch may increase in length by a millimeter but certainly no more; it therefore does not appreciably shorten or lengthen during growth, an amazing fact when regard is had to the great size of the teeth in the australopithecine group.

The dentition in detail

Differences in tooth size have been tabulated above. The major contrasts between the dentition of *A. africanus, A. prometheus, Paranthropus* and *Plesianthropus* have been mentioned above and are illustrated in the diagrams demonstrating the growth changes in the australopithecine mandible (figs. 1, 3, and 4). With regard to general dental features,

[1] Professor Dart's terminology is clarified by a quotation from Weidenreich ('36, p. 99): " . . . it is of the greatest importance to determine not only the mandibular arch as a whole but also the anterior part of it which is occupied by the deciduous teeth in childhood. The posterior boundary of the anterior part is directly before M_1. Bolk ('26) called this point 'postlacteon.' . . . I shall use the term 'anterior alveolar arch' for this pre-postlacteon arch and the reader is to understand that under the term 'alveolar arch' the complete arch is meant."
—Ed.

it should be noted that in the first place the 5-cusped second milk molar of *A. prometheus* (12.5 × 10.5 mm) is somewhat larger than either that of *A. africanus* (11.7 × 10.7 mm), *Plesianthropus* (11.0 × 9.0 mm) or *Paranthropus* (12 × 9.7 mm). Secondly, a relative increase in broadness of the anterior halves of the permanent molars in *A. prometheus* is characteristic. Thirdly, another characteristic is the inequality of the two medial cusps owing to an increase in the antero-posterior length of the antero-internal relative to the postero-internal cusps in *A. prometheus.* Fourthly, there is a relative increase in transverse width of the antero-external cusps (and also in the general size of the intermediate-external cusps) in *A. prometheus* as compared with *A. africanus.*

The general result is that the postero-medial cusps of the molars which are relatively large in *A. africanus* (i.e., approximately equal in size to the antero-internal and antero-lateral cusps) are reduced to about half the size of these cusps in *A. prometheus,* and are only of about the same size as, or actually smaller than the centrally-placed 5th (or postero-lateral) cusp in both the first and the second permanent molars. This arrangement of the 5 main cusps in *A. prometheus* emphasizes the broad contact of the antero-medial and intermediate-lateral cusps at the antero-posterior furrow, whereby the antero-lateral cusp is prevented from meeting the postero-medial cusp. In these features and the absence of a 6th cuspule the permanent molars may be broadly compared with those of *Paranthropus,* rather than with those of *A. africanus,* save that the promethean molars are larger teeth and the cingular furrow and cuspules on the antero-external cusps are much more marked in *A. prometheus* than in any other known australopithecine form (vide plate 2).

The incisors, owing to pre-fossilizational loss, are not available for description. The tip of the right canine has been exposed lying 3 mm below the bone orifice of its eruption canal.

The second right milk molar (10 × 12 mm) is of approximately the same size as that of *A. africanus* but differs from

it, as we have seen, in its more nearly square form, the increased size of the antero-internal cusp, the decreased size of the postero-internal cusp, the enlarged central 5th (or postero-external) cusp and in the apparent absence of a 6th cuspule. It is also very different from the narrow milk molar of *Paranthropus*, which has not only a rudimentary 6th cuspule like *A. africanus* but also a small subsidiary cusp between the two inner (or lingual) cusps.

The first premolars are, like those of man and other australopithecines, broader than long (11.5 × 13.0 mm) when fully erupted, and furnished with outer and inner cusps connected by a ridge, over which passes the deep antero-posterior furrow connecting the pronounced anterior and posterior pits. The first premolars of *A. prometheus* rather resemble, in their general morphology, the second lower premolars of the gorilla, except that they are broader teeth and the cusps are not so high. Strongly developed enamel ridges, continuous with the lateral and medial cusps, respectively, bound the anterior and posterior fovea; each anterior ridge being indented by a medially-running groove continuous with the anterior fovea, and the posterior ridge being divided off from the lateral cusp in the left premolar by a laterally-running groove continuous with the posterior fovea. In the right premolar there is no such lateral groove to disturb the continuity of the posterior enamel ridge with the lateral (or antero-external) cusp. There is, however, on the rounded and inwardly-sloping lateral aspect of each of these teeth of decidedly human form a slight anterior and posterior elevation and roughening of the enamel reminiscent of the anthropoidal cingulum. The first premolars also differ somewhat from the corresponding teeth in *Paranthropus* by being larger teeth, but detailed comparison must await the discovery of better, unworn specimens of *Paranthropus*, more especially in view of the slight divergences in pattern displayed by the two first premolar teeth present in this jaw.

The second premolar, which is only visible on the left side, presents a crown pattern of deep interest, because it differs

so considerably from the corresponding teeth in *Plesianthropus* and *Paranthropus,* which are described as approximating in pattern the second premolars of living anthropoids. In *Plesianthropus* (where a transverse ridge connects the two main cusps as in living anthropoids) the condition, whereby the antero-posterior furrow runs across the ridge to unite the anterior and posterior fovea, resembles that found in the gorilla (Broom, p. 68). In *Paranthropus* there is a deep antero-posterior furrow, as in man; yet, except that the cusps are lower, the structure of the crown is essentially like that in chimpanzee and gorilla teeth (Broom, '46, p. 104):

> In the crown of the Plesianthropus tooth the part behind the transverse furrow is less than a third of the crown. In this it resembles human type. In the Paranthropus tooth the posterior part is more than a third of the crown, and in this it resembles the anthropoid condition. In Paranthropus the anterior fovea is much smaller than in Plesianthropus and in this also the one resembles the anthropoids and the other man (Broom, '46, p. 65).

The tooth in *A. prometheus* is utterly unlike the second lower premolars of anthropoids, it might even be described as ultra-human. There is no ridge whatever connecting the low cusps; consequently the antero-posterior furrow between the cusps has the same depth as the anterior foveal depression and the posterior transverse furrow (or posterior fovea). There are two vestigial cuspules in front of the small anterior fovea and the three bolder cuspules on the enamel ridge behind the posterior fovea (vide plate 2). The most lateral of these posterior cuspules is in linear series behind the lateral (antero-external) cusp. The lateral cusp is not merely very low but is subdivided into three cuspules of which the central one happens to be the most, but still an inconspicuously elevated cuspule. The low rounded antero-internal cusp is thus the most salient cusp in this remarkable tooth.

The first permanent lower molars display appreciable wear of the 3 lateral cusps. These molars correspond with those of human beings in having 5 well developed cusps but there is no trace whatever of a 6th cuspule such as is certainly present

in *A. africanus* and may have been present in *Paranthropus*. Although the antero-internal cusp in *Paranthropus* is larger than the antero-external cusp, it is not sufficiently large to disturb profoundly in *Paranthropus* the cruciform arrangement of the antero-posterior and transverse furrows originally found separating the 4 subequal cusps in *A. africanus*. In *A. prometheus* on the other hand, the antero-internal cusp (or metaconid) is so enlarged, and the antero-external cusp (or protoconid) and especially the postero-internal cusp (or entoconid) relatively so reduced, that the antero-posterior and transverse furrows assume almost an X-shaped disposition diagonally across the tooth reminiscent of the Dryopithecine arrangement. The outer posterior limb of this X-arrangement of the furrow pattern is met by the deep diagonally-running furrow separating the greatly-enlarged and centrally-disposed 5th (or postero-external cusp) or hypoconulid from the intermediate external cusp or hypoconid. As both of the posterior furrows are continued over the crown onto the posterior aspect of the tooth a posterior fovea can scarcely be said to exist(particularly on the right tooth), but there is a distinct anterior fovea present in each tooth.

This X-shaped appearance of the main furrows is emphasized by the forward extension of the transverse furrow from a pit situated between the anterior and middle lateral cusps into an anteriorly-running cingular furrow. This cingular furrow separates a laterally-disposed enamel ridge from the main mass of the antero-external cusp. In *Paranthropus* and *A. africanus* the transverse furrow between the anterior and middle lateral cusps ends laterally in a similar pit between the two cusps but it has no such lengthy forward extension in these forms as that which we find in *A. prometheus*. No account is yet available of the first or second lower molar in *Plesianthropus*, but if the third molar is a fair reflex of the dentition the plesianthropoid type also displayed some evidence of a cingulum in this region.

As a result of the extension backwards of the antero-internal cusp and the presence of the cingular furrow and

cuspule on the antero-external cusp the main antero-posterior furrow is displaced medially as compared with the approximately central position it assumes in *Australopithecus africanus.* Hence, in *A. prometheus* as in *Paranthropus,* the antero-internal cusp occupies about two-fifths of the width of the tooth anteriorly and the antero-external cusp about three-fifths. Owing chiefly to the great size of the 5th cusp (which occupies most of the posterior border of the tooth) and the inward extension of the middle lateral cusp, the reduced postero-internal cusp only occupies about one-quarter of the transverse width of the tooth posteriorly and is thus in sharp contrast with the morphology this cusp presents in the other two known forms *(A. africanus* and *Paranthropus).*

Except for the inward slope of the obtusely-blunted middle-lateral cusp the outer aspects of all the first molar cusps are, like those of *Paranthropus,* more vertically disposed and the teeth are thus more cubical than in *A. africanus.* The cusps are also in general bolder and smoother; they lack the finer folding of the enamel surface on the central aspects of the cusps found in the unworn first permanent molars of *A. africanus.*

The second permanent lower molars, being unworn, display the same bold and smooth cuspal pattern. Save that they are larger teeth, they reveal the same general morphology as is exhibited by the first permanent molars. Only a few minor points of divergence require to be noted.

There is a furrowing of the posterior aspect of the large antero-internal cusp and this furrow marks the lingual border adequately to betray a tendency towards the formation of a separate cuspule in this region between the large antero-internal and small postero-internal cusps. Such a tendency was apparently brought to fruition in the third lower molars of *Plesianthropus* to produce the little secondary cuspule found in this situation in that type. Such a secondary cuspule might even be said to be present on the right second permanent molar of *A. prometheus;* it is not so distinct on the left second molar, but is definitely suggested there as well.

The anterior fovea is distinct and double-pitted; and the enamel ridge bounding it anteriorly displays a slight cuspular elevation centrally between the two pits. The cingular furrows on the antero-external cusps are even more distinct and the cingular ridges broader than those on the first permanent molars. Each cingular ridge displays also a slight irregularity of the upper border and therewith a tendency to form two cuspules. Although these cingular ridges are continued posteriorly into the middle lateral (or buccal) cusp, the main transverse furrow is continued over the cingular ridge onto the lateral aspect of each second molar tooth. (Such a lateral continuation of the transverse furrow is present on the lateral aspect of the left first permanent molar also, but it is absent from the right first permanent molar.)

On these second molar teeth, too, the posterior furrows indent the crown and are carried down somewhat on the posterior aspect of the teeth so that the posterior fovea between the postero-internal cusp and the bulging and centrally-disposed postero-external cusp is only faintly indicated in each tooth.

DISCUSSION

From the occiput previously described and the mandible forming the subject of this communication, the Central Transvaal has been shown to have been the stamping ground of a big-brained australopithecine species with massive jaws and teeth. They were erect and employed bludgeons in human fashion to kill one another, as well as the big game that they hunted and upon which they subsisted.

Previously, when describing the occiput, I pointed out that if, following Simpson ('45), the Pongidae and Hominidae are rightly reduced to "sub-family" rank in a single enlarged family, the Hominoidea, then it seemed probable from all the evidence allying the Australopithecinae with man that the whole so-called "sub-family" of Australopithecinae has nothing more than "generic" rank within the new "sub-family" Hominidae. The evidence afforded by this mandible and its

dentition reinforces that conclusion by portraying the promethean species as distinct and progressive not only in many of its cranial and cerebral features but also in its mandible and dentition, yet preserving the essential characteristics of the australopithecine group and displaying simultaneously, in the teeth more particularly, features that link all the 4 known australopithecine types intimately together. Despite the morphological divergences noted hitherto between the 4 members of the australopithecine group, the range of variation they exhibit is paltry compared with the range of dental variation found in the dryopithecine genus, nor to my mind does it exceed the range of anatomical variation that occurs in any other genus in the pongid and hominid sub-families. If Broom is right to emphasize the divergences within the South African group by creating three genera, I should now properly be creating a further or 4th genus. Rather, by retaining *A. prometheus* (which diverges further from *A. africanus* in some respects than does either *Plesianthropus* or *Paranthropus*) in the same genus as *A. africanus,* I stress the close affiliation between, and common status of the 4 types. The other three may have been separated geologically from *A. africanus;* but geographically *A. prometheus* was less than 200 miles distant from its geological contemporary, *Plesianthropus,* a negligible distance for terrestrial bipeds in open savannah country and one that is infinitesimal when compared with the hemi-global distribution of the dryopithecid genus. It is quite possible that *Paranthropus* also was a contemporary with *A. prometheus.*

As Ruggles Gates ('48) has recently pointed out there are and probably will long remain the practice of the two classificatory attitudes, in respect to living and fossil human and proto-human remains, namely, splitting and lumping. But I have not been able, even assuming a liberal application of the splitting technique, to discover enough divergence anatomically between these 4 creatures to justify the creation of 4 genera to mark what is, after all, the single proto-hominid phase of human evolution that they severally depict in con-

tradistinction to the next or Pithecanthropid-Sinanthropid (generic) phase. Clearly, too, if this lumping attitude is a mistaken one and the australopithecine groups in South Africa must be split into 4 genera, wholesale revision of the dryopithecid genus is an early imperative.

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1 Photograph taken during the course of developing the lower jaw from the breccia. (About $1\frac{1}{8}$ natural size.)

2 Occlusal aspects of mandibles of *Australopithecus africanus* (above) and *Australopithecus prometheus* (below) for comparison. (Natural size.)

An Anomaly of the Pelvic Colon.— Two cadavers showing marked elongation of the pelvic colon have recently come into the Department. Both are from the Buganda tribe; one is male, the other female.

In the male specimen the transverse colon and splenic flexure are normal; the descending colon (devoid of mesentry) descends to the false pelvis where the gut loops forward and passes upward in front of the descending colon proper as high as the splenic flexure. Here it bends anteriorly and to the right and descends on the left psoas muscle to the left sacroiliac articulation where it becomes rectum. The lower two-thirds of the ascending portion has a short mesentery derived from the peritoneum covering the descending colon proper. but the upper part of the descending portion and the whole of the descending portion has a mesentery two inches broad derived from the peritoneum of the posterior abdominal wall. A narrow band of peritoneum passes from the upper surface of the second bend to the under surface of the splenic flexure.

In the second (female) specimen, the transverse colon is again normal but at the splenic flexure the gut makes a sharp loop upwards, then to the right and downwards behind the end of the transverse colon. The colon now passes downwards and medially to the midline at the sacral promontory and is devoid of mesentery. From the sacral promontory the colon passes sharply laterally and upwards to the iliac crest in the mid-axillary line. Here it turns sharply downwards and then passes horizontally to the right and crosses the end of the first descending portion at the sacral promontory and becomes rectum at the right sacroiliac joint. The loop of bowel at the sacral promontory has a short mesentery derived from the peritoneum covering the lower portion of the descending colon. The remainder of the gut to where it becomes rectum has a definite mesentery attached to the posterior abdominal wall for three inches at the level of the disc between the 4th and 5th lumbar vertebrae.

Persistent dilatation of the colon from early childhood resulting from the very bulky African diet and the consequent stretching of the mesentery of the pelvic colon may in part explain the very mobile colon of the African and the concomitant tendency to volvulus. Alexander Galloway. Department of Anatomy, Makerere College. Uganda, East Africa.

(This note recalls two racial studies on the colon published earlier in this Journal: vol. 8. 1925, p. 11; n.s., vol. 1, 1943, p. 313.—Ed.)

AN EXPERIMENTAL APPROACH TO THE MECHANICAL SIGNIFICANCE OF BONE FORM

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THREE FIGURES

An important part of our concepts of prehistoric man must depend on our knowledge of his physical capacities. Since measurements of such attributes as strength cannot be made directly, the shape of bones and location of their various protuberances have often been the bases for speculation as to their dynamic significance. The concepts thus derived have seldom received experimental verification. The purpose of this report is to suggest a method by means of which these inferences can be tested experimentally, and to show the results of applying this approach to a specific problem.[1]

The subject selected for analysis was the efficiency of flexing and supinating movements of the forearm, as affected by the position of the bicipital tuberosity of the radius (Radial tuberosity in B.N.A.) and the degree of bowing of this bone. Conspicuous anatomical differences exist between modern man, Neandertal man, and the anthropoids. As remarked by Boule ('23) and shown in figure 1, the more distal position of the bicipital tuberosity and the greater curvature of the

[1] We acknowledge gratefully the interest and cooperation of Professors J. B. deC. M. Saunders of the Division of Anatomy and T. D. McCown of the Department of Anthropology in furthering this project. We further acknowledge a debt to Prof. Loren Eiseley, of the University of Pennsylvania, in that in a personal communication in 1943 he posed questions which led to the problem selected and the technique described herein.

radius in the Neandertaler correspond more closely to the structure of the gorilla radius than to modern man. The observations of Yerkes ('29) and others have shown that the gorilla forearm possesses proportionately greater strength in flexing and supinating than does that of modern man. Thus the structural similarity of the radius of the gorilla and of Neandertal man might justify the assumption of greater strength of the latter's forearm than is found in modern man.

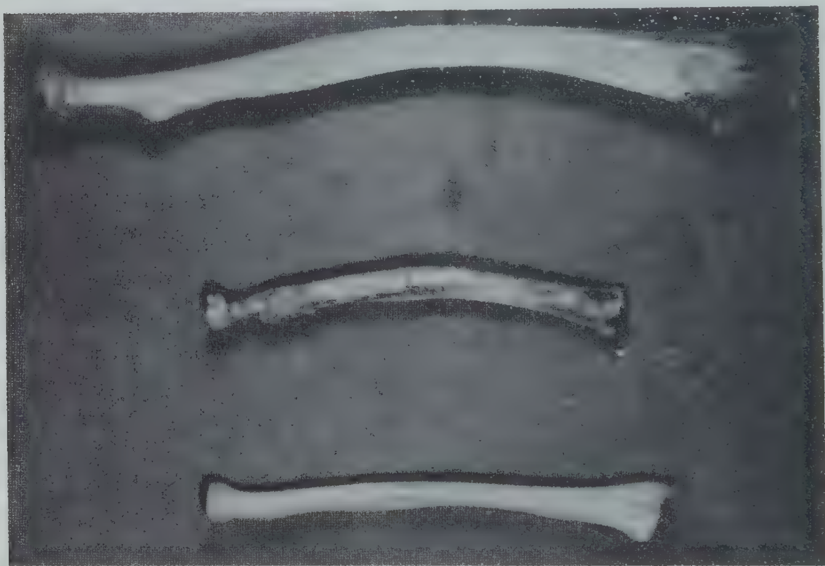

Fig. 1 Curvature of radius and position of its bicipital tuberosity. From top to bottom: G. gorilla (courtesy California Museum of Vertebrate Zoology), H. neandertalensis (cast, courtesy The Anthropological Museum), H. sapiens.

In attacking this problem experimentally, human cadaver material was obtained from the Division of Anatomy of the University of California Medical School. The upper extremity was disarticulated at the shoulder. The hand and the muscles of the arm and forearm were removed. The humerus, radius, and ulna thus remained, held together at the elbow by ligaments in a natural, freely-moving articulation.

For tests in flexion the humerus was clamped in a vertical position, and the radius and ulna left free to move (fig. 2). A cord suspended from the pan of a laboratory balance was attached to the radius at the bicipital tuberosity to simulate the attachment and direction of pull of the M. biceps brachii. The length of the cord was adjusted so that the forearm was suspended approximately 15° below horizontal, at an angle of about 105° with the humerus. It could undertake an excursion in flexion of approximately 30° when an adequate force was applied to the other pan of the balance. The forces consisted of varying volumes of water; the magnitude of the force was determined by measuring the volume of water, on the assumption that 1 cm^3 weighs 1 gm. The addition of water to the flask was performed slowly, to minimize the effects of inertia which might have attended sudden rapid changes in the volume. The attainment of balance was accompanied by slow but perceptible movement of the forearm through its permitted excursion.

In the course of repeated observations each preparation reproduced its performance quite constantly under a given set of experimental circumstances. The following tabulations illustrate representative collections of data as actually collected during a single observation period, rather than averages computed from all observations.

The effect on flexion of individual variations in site of the biceps attachment was studied in preparations in which pull was applied through a fragment of the biceps tendon which had been left on the bicipital tuberosity. Table 1 shows the results obtained in 4 such preparations. Each was first made to flex in the absence of a load. The increment of force which was necessary to produce flexion after the addition of a 50-gm load was then measured. It will be seen that the ratio of this increment to the added load varied from 4.8 to 7.6.

It is noteworthy that the force applied through the biceps tendon in these observations was exerted over an area rather than at a point on the bone. The tension on this tendon appeared to be developed in its most distal fibers initially. Dur-

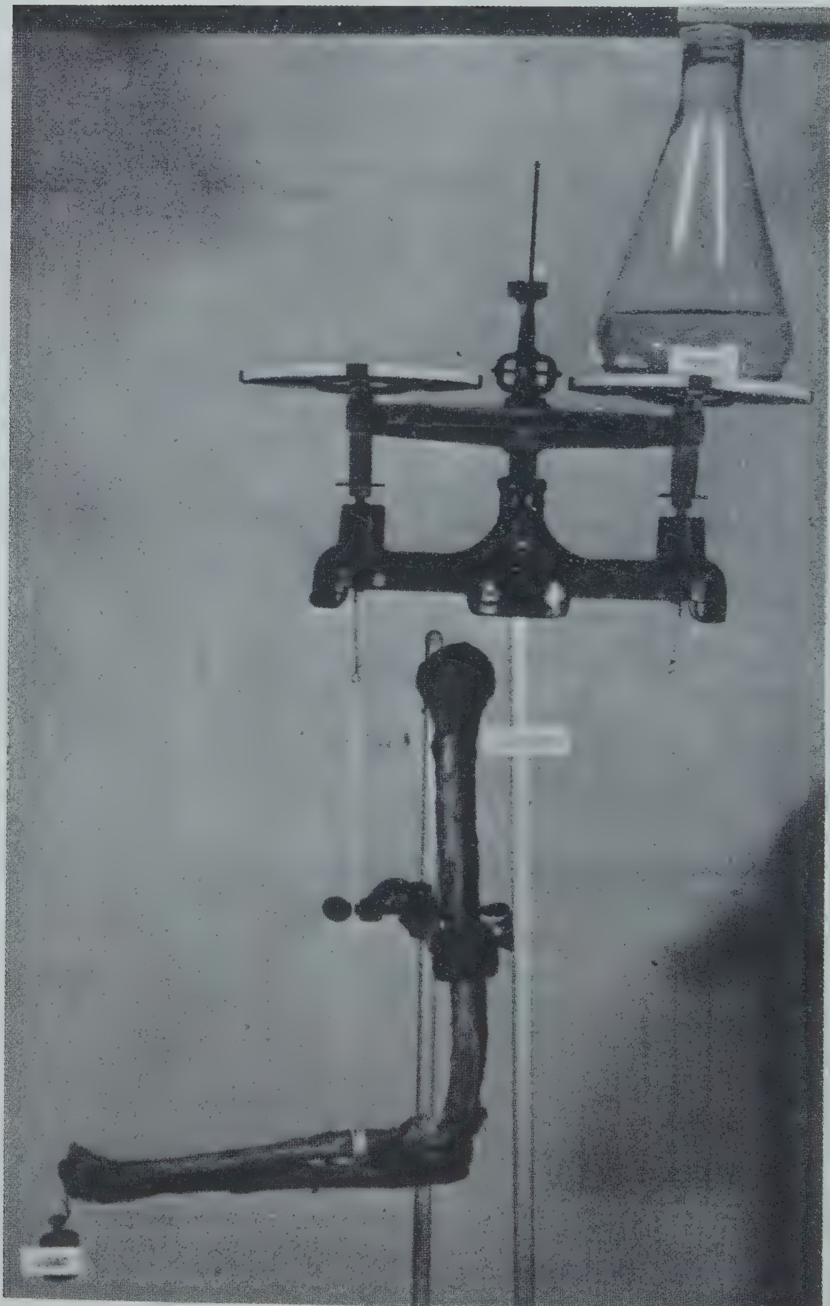

Fig. 2 Upper extremity; method for testing flexion.

ing flexion there appeared to be a shift of the region of greatest tension toward the more proximal fibers. Thus, the region at which force was applied migrated slightly during the excursion, in a direction which would decrease the efficiency of the lever. The individual variations may have resulted in part from this circumstance as well as from variations in position of the bicipital tuberosity.

Table 2 shows the results of applying the flexing forces at a point, and of varying the distance of this point from the proximal end of the radius. The cord leading from the balance was first attached to the radius at the midpoint of the crest of the bicipital tuberosity. This point, T_1 in table 2, fell 31 mm from the proximal end of the radius, which was 230 mm long. This proportion, 13.5% of the bone's length, had been selected on the basis of measurements of 10 left radii from the osteologic collection. The amount of force necessary to effect flexion of the preparation, both unloaded and with a load, was determined. The attachment of the cord was then moved distally 3.5 mm, to a point 15% of the bone's length from the proximal end. This position, T_2 in table 2, was selected on the basis of measurements of a reproduction of a cast of a Neandertal radius. The amount of force which would cause flexion was again determined.

TABLE 1

Variations in different preparations in the relation of flexing force to load

PREPARATION	FORCE APPLIED		INCREMENT OF FORCE	RATIO OF INCREMENT TO LOAD
	Without load	50 gm load		
	gm	*gm*	*gm*	
1	735	975	240	4.8:1
2	745	1030	285	5.7:1
3	670	990	320	6.4:1
4	635	1035	380	7.6:1

It is evident from table 2 that less force was required to produce flexion of the forearm when it was applied more distally. With the attachment at T_1 an increment of force

of 85 gm was required to move an added load of 10 gm; when acting at T_2 an increment of only 55 gm sufficed to move the same load. It is also noteworthy that the force which, acting at T_1, would move the forearm and a 10-gm load corresponded to that which, acting at T_2, would move the forearm loaded with 40 gm.

It thus appears that even this slight displacement of the point at which the flexing force was applied was sufficient to produce differences of appreciable magnitude in the preparation.

TABLE 2

Tests in flexion, with variation in point of application of force

LOAD	POINT OF APPLICATION OF FORCE					
	T_1 [1]			T_2 [1]		
	Force applied	Increment of force	Ratio I:L	Force applied	Increment of force	Ratio I:L
gm	*gm*	*gm*		*gm*	*gm*	
0	940	..	....	795	..	..
10	1025	85	8.5:1	850	55	5.5:1
40	..	..	..	1030	180	6:1

[1] T_1 — A point 31 mm from proximal end of radius (crest of bicipital tuberosity).
T_2 — A point 34.5 mm from proximal end of radius (3.5 mm distal to crest of bicipital tuberosity).

For tests in supination the ulna was clamped in a fixed horizontal position (fig. 3). At rest the radius lay below the ulna in a position of pronation. It was thus free to rotate almost 180° into complete supination. During tests the humerus was supported in partial flexion. The cord was attached by a rolling hitch midway on the length of the radius, corresponding to the insertion of the most distal fibers of the M. supinator. The force was first applied directly on the bone's surface (S_1 in table 3). The attachment of the cord was then built up with cork 4 mm thick (S_2). The effect of this was to increase the subtense of the chord of the radius; it thus simulated the bowing of the Neandertal radius, and was well within the range of the chord which has been reported for this bone by McCown and Keith ('37, '39).

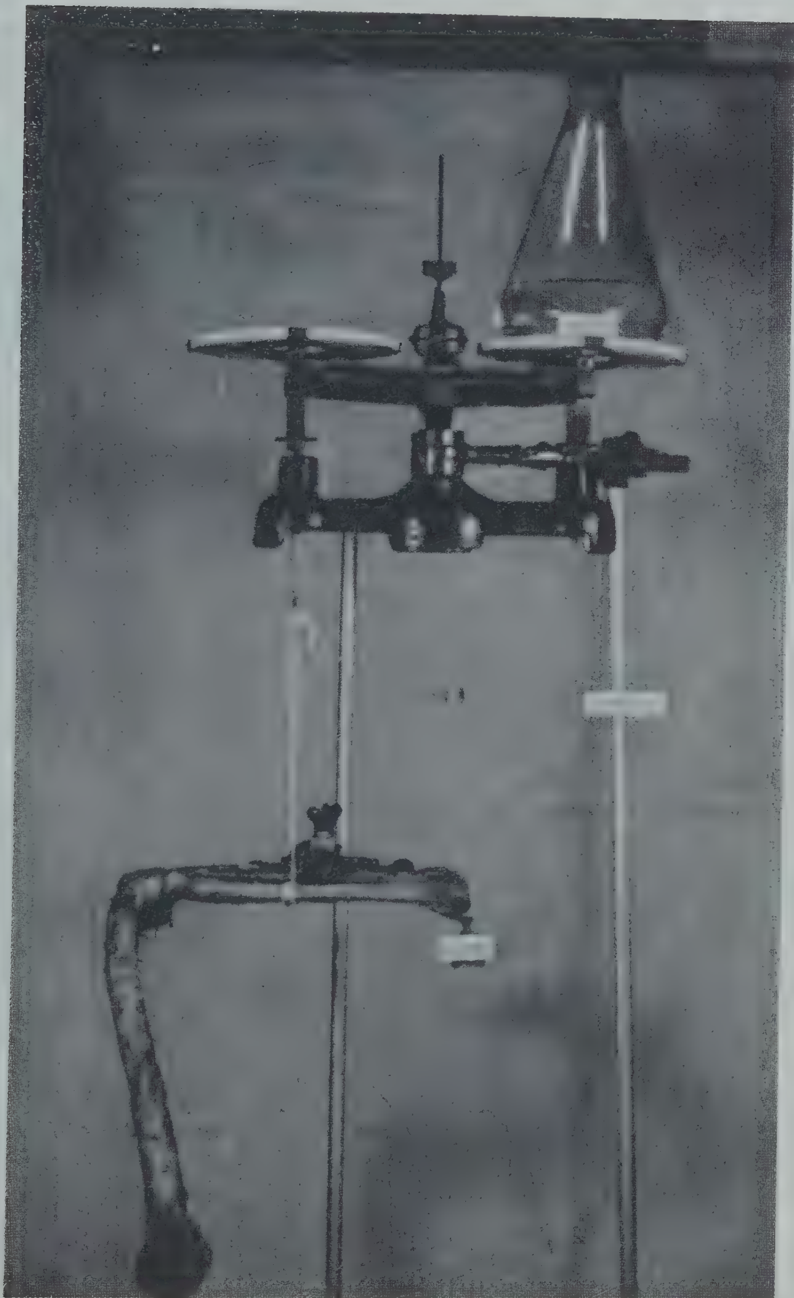

Fig. 3 Upper extremity; method for testing supination.

Table 3 shows the forces necessary to supinate such a preparation when applied at S_1 and S_2, and the increment of force necessary to supinate against an additional 50-gm load.[2] With the supinating force acting at the bone's surface the increment of force required was equal to twice the load added. With the chord subtense built up to simulate an additional bowing, the increment of force needed to move the same weight was much less; in fact, in this experiment it was just equal to the added load. Thus this slight alteration in attachment of the force sufficed to produce a marked alteration in its capacity to move against a load.

TABLE 3

Tests in supination, with variation in point of application of force

LOAD	POINT OF APPLICATION OF FORCE					
	S_1 [1]			S_2 [1]		
	Force applied	Increment of force	Ratio I:L	Force applied	Increment of force	Ratio I:L
gm	*gm*	*gm*		*gm*	*gm*	
50	410	..	..	280	..	.
100	510	100	2:1	330	50	1:1

[1] S_1 — On surface of radius, at attachment of M. supinator.
S_2 — 4 mm above surface of radius, built up over attachment of M. supinator.

In the analysis of these results, it is important to remember that no absolute measurements of strength have been attempted. Major physical and physiological forçes have been omitted from consideration in favor of simplicity of technique. For example, an exact computation of the forearm's capacity to act as a lever of the third class has not been made, due to the complexity of the problem of the fulcrum in this instance. From the physiological standpoint, the dynamics of a muscle under varying degrees of tension affect the contraction. Blix' law states that there is a certain optimal stretch of mus-

[2] All basal measurements in supination were made with the preparation bearing a 50-gm load, since without this load the preparations were not heavy enough to return to the starting position of pronation.

cle at which the force of contraction is maximal. This phenomenon would doubtless play a part in the interpretation of the effect of variations in the site of a muscle's attachment.

These and other considerations would allow room for devising many refinements of the technique. One of special interest would be the decalcification of a bone, the alteration of its shape to conform to the pattern which is to be studied, and the reconstitution of the bone's rigidity in the new pattern by infiltration with lime salts.

Even in its simplest form, however, as presented in this report, it should prove possible to conduct experiments respecting the functional importance of many of the differences in primate skeletal structure.

In summary, this report demonstrates that: (1) the concepts of the mechanical significance of muscle attachments, as indicated by skeletal features, may be subjected to simple experimental tests on readily available material; (2) modification of these attachments in cadaver material may be performed to simulate the structural features found in unavailable material; and (3) tests thus performed on flexion and supination of the forearm offer substantiation of the statements that the peculiarities of the radius of H. neandertalensis indicate an efficiency in these movements greater than that of modern man. Quantitative estimates of these differences are not presented, since it is likely that variables not measured by this technique may have played a role in flexion and supination under physiological conditions.

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Anthropological News from Argentina.— The *Boletín Bibliográfico de Antropología Americana* (vol. 10 for 1947, Mexico, 1948, pp. 9–15) brings news of some of the changes that the scientific institutions of Argentina underwent during 1947. It is especially noteworthy that in Buenos Aires the anthropological collections of the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia" (Ave. Angel Gallardo 450) were transferred to the Museo Etnográfico (Moreno 350). Since the latter museum and the Instituto de Antropología are both under the Facultad de Filosofía y Letras of the Universidad de Buenos Aires, probably this was considered to be a logical place to center anthropological interests. José Imbelloni is director of the Instituto.

The transfer involves 72,000 specimens of which 60,000 are in archeology, 7,000 in ethnology and 5,000 in physical anthropology. Among the last are included 82 face masks (mostly African) and cranial series from La Puna de Jujuy (Paulotti collection), from the Argentine Northwest (Zabaleta collection), from Río Negro (Pozzi collection) and from Chanchan, Perú (Imbelloni collection).

S. L. Washburn of The University of Chicago returned in September from a 5-month visit to South and East Africa, financed by a grant from the Viking Fund. In South Africa he studied the sex differences in the pelvis of Bushmen and Bantu, using material in the museums at Cape Town, Johannesburg, Kimberley and Pretoria. These data show no overlapping between males and females in the Bush race. This is the only race in which such extreme differences have been demonstrated. Doctors Broom and Dart generously showed Doctor Washburn their collections of fossil ape-men, including two new mandibles found last summer. Doctor Washburn is convinced that the pelvis belongs with the ape-man material and is not human, as some have suggested. In East Africa, Dean Galloway, of Makerere College Medical School (in Kampala, Uganda), welcomed Doctor Washburn and made it possible for him to obtain a fine collection of 100 monkeys. All of these were skeletonized and many dissected in the laboratory at Makerere. The dissections included observations on the growth of the muscles of mastication intended to relate the changes in these muscles to modifications in the skull.

BLOOD GROUPS OF WHITES, NEGROES AND MULATTOES FROM THE STATE OF MARANHÃO, BRAZIL [1]

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Within the Brazilian "melting pot" the intensity and variation of the racial mixture rises to a high point in the State of Maranhão. Of the three main races entering into this mixture, Indian, Negro and White, remnants are still to be found in more or less pure condition. As would be expected, however, all possible combinations of these primary groups are now abundantly present. Thus the population of this State presents unusual opportunities for research in the problems of physical anthropology growing out of race mixture.

The present study deals with the classical blood groups in Whites and Negroes and in mixtures of these two races. The observations were made in the city of São Luiz and in the village of Santo Antonio dos Pretos (Municipe of Codó), a little over 300 km southeast of the former.

The Negroes were selected on the basis of their well-known physical characteristics. The series totals 198 and includes representatives of different African groups.

The Whites are mainly from Arabian (Syrian) stock, with some Portugese and a few Spanish individuals. The series totals 196.

The individuals of mixed origin, which we will call Mulattoes in accordance with Brazilian custom, are mostly if not all first generation crosses. Selection was made by examining

[1] Aided by a grant from Dr. Guilherme Guinle.

the physical characteristics and seeking information from the people themselves. There are 146 in this group.

The frequencies of the 4 common blood groups are shown in table 1.

The findings for the Negroes are very close to those for different African groups, especially the Bantus, assembled by Boyd ('39, p. 160). The main difference between the Bantu and the Negroes of this sample is in the frequency of group AB. My figure of 7.6% is above the highest (3.8%) thus far reported for the Bantu.

As for the Whites of Maranhão, the distribution is essentially the same as found in other white populations, particu-

TABLE 1

Distribution of blood groups in three racial groups of Maranhão

RACIAL GROUP	NO.		BLOOD GROUP O	A	B	AB
Negroes	198		110	34	39	15
		%	*55.5*	*17.2*	*19.7*	*7.6*
Mulattoes	146		72	43	21	10
		%	*49.3*	*29.5*	*14.4*	*6.8*
Whites	196		83	67	19	27
		%	*42.3*	*34.2*	*9.7*	*13.8*

larly among Syrians (Boyd, '39, pp. 180–181). The value of AB in Maranhão Whites (13.8%) is high, but is not far above Boyd's figures of 12.5% for Aquedat Bedouin. On the other hand, the value of B is low but not as low as in some of the Bedouins. I have no explanation for this frequency distribution. In any case, however, the values of p and q (table 2) are almost identical with those of a "typical white population"; that is, with the average of numerous determinations performed on Whites.

As can be seen from table 2, the difference D in the case of Negroes (0.025) attains three times the S. D. ($\sigma = 0.0082$) while in the case of Whites, the ratio D/σ approaches 5. This

may reflect the relative degree of heterogeneity in the populations concerned.

Finally, the series that is of particular interest in this study, the Mulatto, requires more detailed analysis to show what we have assumed to be the case, namely, that it represents a first generation cross between the Whites and Negroes.

TABLE 2

Gene frequencies in three racial groups of Maranhão

RACIAL GROUP	NO. V	FORMULA [1]	GENE FREQUENCIES p	q	r	DIFFERENCE [2] D	STANDARD DEVIATION OF D [3]
Negroes	198	a	.133	.147	.745	.025	.0082
		b	.108	.122	.745		
		mean	.121	.135	.745		
Mulattoes	146	a	.202	.112	.702	.016	.0105
		b	.186	.096	.702		
		mean	.194	.104	.702		
Whites	196	a	.279	.125	.651	.055	.0119
		b	.224	.070	.651		
		mean	.252	.098	.651		

[1] Formulae for calculating gene frequencies:

a: $r = \sqrt{\bar{O}}$ $p = 1 - \sqrt{\bar{O} + \bar{B}}$ $q = 1 - \sqrt{O + \bar{A}}$

b: $r = \sqrt{\bar{O}}$ $p = \sqrt{A + \bar{O}} - \sqrt{\bar{O}}$ $q = \sqrt{B + \bar{O}} - \sqrt{\bar{O}}$

[2] $D = (p + q + r) - 1$

[3] $\sigma_D = \sqrt{\dfrac{pq}{2V\,(1-p)\,(1-q)}}$

Following Prof. Ottensooser's advice, I have applied a simple algebraic calculation exemplified in one of his papers (Ottensooser, '44) for the calculation of the proportion of racial mixture represented by the Mulattoes from the gene frequencies of all three groups given in table 2. We will let p_m and r_m be the frequencies respectively of genes p and r in the Maranhão Mulattoes. Then p_n and r_n will represent in the same way the Maranhão Negroes, and p_w and r_w the

Whites. Gene q will not be considered because the frequencies are low. Employing gene p the following formulae are used:

$$\frac{p_w - p_m}{p_w - p_n} = \%\ \text{Negro} \qquad \frac{p_m - p_n}{p_w - p_n} = \%\ \text{White}$$

Substituting:

$$\frac{.279 - .202}{.279 - .133} = \frac{.077}{.146} = 52.7\%\ \text{Negro} \qquad \frac{.202 - .133}{.279 - .133} = \frac{.069}{.146} = 47.3\%\ \text{Whiite}$$

Gene r gives quite similar results, as follows:

$$\frac{r_m - r_w}{r_n - r_w} = \%\ \text{Negro} \qquad \frac{r_n - r_m}{r_n - r_w} = \%\ \text{White}$$

Substituting:

$$\frac{.702 - .651}{.745 - .651} = \frac{.051}{.094} = 54.3\%\ \text{Negro} \qquad \frac{.745 - .702}{.745 - .651} = \frac{.043}{.094} = 45.7\%\ \text{White}$$

In spite of this agreement, we can say only that the Mulattoes are approximately half-White and half-Negro because the differences are statistically significant only as between Whites and Negroes.

There is still another way to arrive at approximate values for the proportions of the two races represented in the mixture. There are two sets of formulae for the calculation of the incidences of p and q. Table 2 shows that the difference between the sum of the three gene frequencies and 100% is always the same, regardless of the set of formulae used. To minimize this difference, each frequency was calculated by both formulae, and the mean of the resulting frequencies used as a corrected frequency. Summation of the corrected gene frequencies comes to 100% (or 100.1%).

Accordingly, we will represent these corrected gene frequencies by the symbols p_n', p_m' and p_w'. The above formulae thus become:

$$\frac{p_w' - p_m'}{p_w' - p_n'} = \%\ \text{Negro} \qquad \frac{p_m' - p_n'}{p_w' - p_n'} = \%\ \text{White}$$

Substituting the mean frequencies from table 2:

$$\frac{.252 - .194}{.252 - .121} = \frac{.058}{.131} = 44.3\%\ \text{Negro} \qquad \frac{.194 - .121}{.252 - .121} = \frac{.073}{.131} = 55.7\%\ \text{White}$$

These figures, unlike the previous ones, give a higher value for the White component in the mixture.

In considering the results of these calculations, it is important to remember that the serological findings are far from being representative of the population of the State of Maranhão, much less that of the population of São Luiz. We have not taken into consideration an important factor, namely, the mixtures of Indians, both with Whites and Negroes. To have a broader and more accurate view of this subject, however, it would be of little use to investigate a few hundred more individuals, taken from the whole State population, without any selection. It seemed better to us to characterize two of the main components, Whites and Negroes, in order to appraise by means of objective serological tests the selection of their mixture made on the basis of physical characteristics. The serological findings on the Mulattoes, indeed, confirm our assumptions regarding the genetic composition of this group.

SUMMARY

The common blood groups are reported for 196 Whites, 198 Negroes, and 146 Mulattoes living in the State of Maranhão, Brazil. The Mulattoes were selected by physical characteristics and personal information as being 50% white and 50% Negro (first generation crosses).

The gene frequency distribution in the white individuals ($p = .278$, $q = .125$ and $r = .651$) is very similar to other white populations, especially Syrians. This result seems to reflect the predominance of Syrian ancestry among the people examined.

Among the Negroes the distribution ($p = .133$, $q = .147$, $r = .745$) is quite similar to that observed in the Bantus of Africa.

Among the Mulattoes, the gene frequencies are $p = .202$, $q = .112$ and $r = .702$. The assumed genetic composition of this group is borne out by a simple algebraic calculation of

the proportion of racial mixture from known gene frequency.

I am greatlly indebted to Prof. Ottensooser and Dr. W. O. Cruz for their help and advice in the elaboration of this paper.

I am indebted also to Mr. João Vierira, auxilliary of the Department of Hematology, Commandant, officiers and soldiers from Military Police of Maranhão, Dr. A. Bastos Filho, director of Public Health Department of Maranhão, Dr. O. Tenorio Lima, Mr. J. Roland Braga, Marinus Castro, J. Camara Carvalho from National Department of Malarid (Sector of Maranhão) and Mr. Tancredo Lago, from Santo Antonio dos Pretos, for their aid in conducting this work.

The sera used were kindly supplied by Laboratório Paulista de Biologica (São Paulo).

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BLOOD GROUPS OF AMERICAN INDIANS.— It is not clear how one should explain the origin of a few Indian tribes extremely rich in p in the midst of the large American Indian population almost devoid of p. Should one apply the elimination theory here of the r allele in the very small original group, or postulate mutations in old times? The first seems more probable to the present author. On the whole, the elimination theory explains many irregularities of the blood alleles. It makes the scientist less inclined to construct great world-embracing wanderings of peoples in prehistoric times, only on the basis of modern serological values. But, it cannot be denied that the theory of the relative intactness of the Columbian races of America from relatively late, but pre-Columbian invasions from the Old World is strongly supported by the A-B-O serology.— Bertil Lundman. Geography of human blood groups (A, B, O, system). Evolution, vol. 2, no. 3, September, 1948. pp. 231–237, with 5 world maps.

ANTHROPOMETRY OF A MAM-SPEAKING GROUP OF INDIANS FROM GUATEMALA

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FIVE PLATES

During February and March, 1947, the writer measured 61 mature male, Mam-speaking Indians, born and living in the Department of Huehuetenango, in the western highlands of Guatemala. This work was undertaken to obtain comparative data for the study of the skeletons being recovered at Zaculeu, an archaeological site located 2.65 miles southwest of the town of Huehuetenango. Zaculeu is being studied and restored by the United Fruit Co. (Dimick, '47).

This region is located on a high rugged upward-sloping plateau adjoining an abrupt approach to the Cuchamatanes, a part of the high range on the southern boundary of Mexico. The environment in general presents conditions the opposite of those found in the lowlands of the Yucatan peninsula, where studies on the Indian population were carried on by Steggerda ('32), Starr ('02) and Williams ('31).

Zaculeu is generally considered the ancient capital of the Mam group and probably a strong point of occupation by the Mams for several hundred years. According to Mason ('40) and Johnson ('40), the area about the present ruins has been occupied by a Mam-speaking group since at least shortly before conquest days. The area occupied by this group is not large but appears to have maintained its linguistic distinction down to present times. Political leaders may have changed but the local populations probably remained fairly constant.

The nearness of Huehuetenango, a colonial town founded in the 16th century, introduced a difficulty in selecting a sufficiently pure sample. Most of the town population represents many crosses. The surrounding fincas, rancherias and villages, however, seem to have retained much of their ancient strain.

In order to avoid recent crosses, the following criteria were set up for the selection of individuals to be studied: (1) They had to be dressed as Indians and to speak the local Mam dialect, and (2) their identification papers, which are required by law in order to vote, had to state that their parents were of a Mam-speaking group and that they were born in a village or rancheria of that group. A few had adopted western dress but they acknowledged an Indian status and spoke the Mam dialect. Some were selected from the inmates of the local jail at Huehuetenango, from the laborers employed at the excavation site and from workers who delivered produce and supplies from the nearby fincas.

The work was aided by an excellent interpreter and facilities made available by John M. Dimick, Director of the Archaeological Project at Zaculeu, and Stanley Boggs, resident archaeologist.

Methods used are those taught by Dr. Morris Steggerda of the Kennedy School of Missions, Hartford. A wooden anthropometer was procured from the Central Scientific Company, Chicago, and steel calipers from the Swan Tool and Machine Company, Hartford. The writer also had the opportunity of having Doctor Steggerda check measuring techniques frequently before leaving for the field.

The subjects stood without shoes on a heavy flat board. Frequently they were already stripped to the waist or else wore a simple cotton shirt. Measurements and photographs were made with the individual standing. The latter were made in black and white as well as color. As a physician I also made a number of medical observations. All blood pressures were taken standing and sitting, using a tycos spring instrument. The variation between standing and sitting ob-

servations were so insignificant that eventually all blood pressures used in the study were those taken standing. Pulse was counted at the wrist, standing and sitting. Legs were inspected by pulling up the trousers. Only apparently healthy adult males were included.

No attempt at broad comparisons will be made at this time. Byers ('31) and d'Aloja ('39) are the only ones who have measured groups of Indians in the Department of Huehuetenango. Comparative metrical data are presented in table 3, limited to their reported material.

MORPHOLOGICAL OBSERVATIONS

Age. Reliability of age depends upon the interpreter's capacity to procure from the subjects their age, as far as they knew, or in translating from the written voters cards, which many of the Indians carried. The ages and range compare favorably with other studies. Leche, Gould and Tharp ('44), in a study of a series of groups of Mexican Indians related to the Maya, state that their subjects "were all adult males." In reviewing their published photographs, it is apparent that Indians of 15 years were included. On the other hand, Williams ('31) limited his report on the Yucatan Maya to those 18 years or older and did not report anyone over 55. Gould ('46), in reporting measurements of the Chol Indians states, "the ages of the subjects varied from slightly under 20 to nearly 60." He was unable to determine their ages more accurately. Four only were under 20. Steggerda ('32), in his study of 77 male Mayan Indians presented a mean age of 30 years. The Indians included in this study at Zaculeu appeared to be the age given in each instance. None seemed to have aged prematurely and the younger group seemed reasonably well developed with no one representing true retardation. A number of the middle age group appeared to be slightly younger than the years given. The figures obtained are discussed on p. 433.

Hair. The color in all cases was black. Occasionally, there was slight to considerable grayness after age 50. Hair was

straight to an occasional slight wavy type. Mustache and beard showed a moderate to scanty growth. Beard was found on both cheeks down to the mandibular shadow line including chin. In one instance beard was quite coarse, black and profuse, but still less than in Europeans. The mustache was always scanty. Beard grayed with the head hair. An occasional individual showed a tendency to baldness as well as a receding frontal hairline. None was found to manifest this tendency under 40 years of age with one exception, that of a 23-year-old male who showed a partial harelip and cleft palate as well as mandibular overbite. Advanced alopecia was not observed.

Eyes. Only uniformly dark brown eyes were found. There were no light brown, blue or gray eyes. Eye folds of a Mongolian type were noted in two instances. All eyeslits were set slightly obliquely and were relatively long and narrow. The eyelashes were moderate in length and number. Eyebrows were uniformly moderate as contrasted to bushy.

Nose. Many types were observed but the predominate characteristics were convexity with broad to medium bases. A few were straight and none were concave. They were, however, not uniformly as convex as reported by Steggerda for the Yucatan Maya. External nostrils were large. Some observers have reported narrower nostrils basing this characteristic on the assumption that narrow nostrils exclude the cold air of a mountainous environment. Actually, these Indians had relatively large nostrils.

Teeth. But few signs of caries were noted under 30 years of age. Caries attack the second and third upper molars more than any other teeth. The lower incisors showed a high frequency of pyorrhea alveolaris in the older group. This older group also showed moderately elevated incidence of caries in all 12 molars. In the aged group, over 50, the upper incisors began to show signs of caries. Second and third upper molars showed the greatest incidence of loss in those over age 30. Third molars, both upper and lower showed a failure of eruption in 15% of those examined. Irregularity of alignment of teeth in general was 21% with only one case noted

of mandibular overbite. The latter was accompanied by other anomalies mentioned before. The overall picture was one of sound teeth well formed, wearing down more than in Europeans due probably to a coarser diet and the inclusion of fine particles of stone from metates. Heavy collections of tartar were observed commonly in those over 35 years of age. Subjects under 30 years showed surprisingly clean teeth quite white with no dental work whatsoever. The oldest subject, age 65, had lost only 4 molars and showed sound teeth. No measurements were taken of the dentures, but an overall impression was similar to that expressed by Williams. In this respect he has stated that males seem to demonstrate broad dentures with the anterior width greater than in American white males. Shovel-shaped incisors were found quite frequently, but the percentage was not recorded.

Skin. Texture was good to coarse; color, medium brown. No comparative color samples were used in this study. All subjects were sun-tanned with only three showing a tendency to a slightly lighter complexion and freckle formation. The skin of the face, neck and chest was compared with the under arm or axillary skin which was relatively lighter.

Constitutional types. None of the extreme forms of body build as depicted by Sheldon and others were noted. All seemed to come within the intermediate class described as mesomorphic. This study was, of course, weighed in the direction of working males and accordingly, the extreme types probably had been ruled out in advance by employment selectivity.

METRIC DATA

The metrical findings on the Zaculeu group listed in tables 1 and 2 can be evaluated insofar as the available comparative data from the area permit (table 3).

Age. A mean age of 29.7 $\pm$ 1.01 in a group which includes two individuals, age 15, and one of age 65 compares favorably with the results of other investigators. Byers ('31) gave the mean age for his series of highland Indians of Jacaltenango as 25.92 $\pm$ 1.92 and for those of Concepción as 30.54 $\pm$ 1.92.

His minimal age was 15. On the other hand, d'Aloja ('39) selected 19 as her minimal age for males. Her sample, however, numbered only 23. Williams ('31) limited his study of the lowland Maya to those 18 years or older and did not report anyone over 55. Steggerda ('32) in a study of the same group reports a mean age of 30.57 with a range from 15 to 60 years. It would seem, therefore, that the age composition of the present series is comparable to those of the investigators cited.

TABLE 1

Mean and range of measurements (mm), with statistical constants, for a group of 61 Mam-speaking Indians

	NO.	RANGE	MEAN AND P.E.	ST.D. AND P.E.	C. VAR. AND P
Age	61	15–65	29.7 ± 1.04		
Stature	61	1440–1670	1559.7 ± 4.72	54.65 ± 3.34	3.50 ± .2
Supra sternal height	61	1140–1360	1256.2 ± 4.02	46.60 ± 2.85	3.71 ± .2
Acromial height, rt.	61	1125–1400	1278.1 ± 4.68	54.18 ± 3.19	4.24 ± .2
Span	60	1450–1750	1618.3 ± 5.90	67.75 ± 4.17	4.19 ± .2
Tibiali to sphyrion	58	285–385	349.1 ± 1.64	18.5 ± 1.16	5.30 ± .3
Acromion to radiale	58	255–345	308.5 ± 1.44	16.27 ± 1.02	5.27 ± .3
Radiale to stylion	61	200–260	232.1 ± .99	11.5 ± .70	4.95 ± .3
Biacromial breadth	55	315–415	368.6 ± 2.04	22.4 ± 1.44	6.09 ± .3
Chest transverse	59	215–305	269.3 ± 1.52	17.36 ± 1.08	6.45 ± .4
Chest girth	59	690–930	846.1 ± 4.04	46.04 ± 2.86	5.44 ± .3
Chest anterior-posterior	56	152.5–229.5	185.4 ± 1.33	14.8 ± .94	7.98 ± .5
Acromion to stylion	58	455–585	531. ± 2.19	24.68 ± 1.55	4.65 ± .2
Head length	61	167–197	182.0 ± .46	5.31 ± .32	2.92 ± .1
Head width	61	131–157	143.6 ± .43	4.99 ± .30	3.47 ± .2
Foot length	61	200–265	241.0 ± 1.01	11.68 ± .71	4.85 ± .2
Foot width	59	76–116	98.2 ± .69	7.81 ± .48	7.95 ± .4
Hand length	59	147.5–192.5	169.5 ± .77	8.80 ± .54	5.19 ± .3
Hand width	60	59–85	71.9 ± .415	4.76 ± .293	6.61 ± .
Bizygomatic diameter	60	112–148	135.1 ± .48	5.51 ± .34	4.08 ± .
Nasion to gnathion	60	100–136	117.6 ± .59	6.81 ± .42	5.82 ± .
Nasion to stomion	61	64–84	73.8 ± .39	4.54 ± .27	6.15 ± .
Nasion to subnasion	60	43–67	53.3 ± .42	4.92 ± .30	9.23 ± .
Nose breadth	60	31–49	38.3 ± .24	2.78 ± .17	7.26 ± .
Bigonial diameter	61	94–122	105.3 ± .46	7.81 ± .48	7.95 ± .

TABLE 2

Mean and range of indices, with statistical constants, for a group of 61 Mam-speaking Indians

INDEX		NO.	RANGE	MEAN AND P.E.	ST. D. AND P.E.	C. VAR. AND P.E.
Cephalic	$\frac{\text{Breadth}}{\text{Length}} \times 100$	61	68–84	78.8 ± .28	3.12 ± .19	3.97 ± .24
Relative span	$\frac{\text{Span}}{\text{Stature}} \times 100$	60	100–108	103.8 ± .19	2.13 ± .13	2.05 ± .13
Body build	$\frac{\text{Chest girth}}{\text{Stature}} \times 100$	61	45–59	54.4 ± .25	2.88 ± .18	5.29 ± .32
Brachial	$\frac{\text{Rad. to styl.}}{\text{Acrom. to rad.}} \times 100$	58	65–85	75.3 ± .30	3.36 ± .21	4.46 ± .28
Relative acromial breadth	$\frac{\text{Biacrom. breadth}}{\text{Stature}} \times 100$	54	22–26	23.7 ± .10	1.04 ± .07	4.38 ± .28
Trunk	$\frac{\text{Chest transv.}}{\text{Chest. a.–p.}} \times 100$	56	115–165	145.4 ± .99	11.0 ± .70	7.57 ± .48
Facial	$\frac{\text{Nas. to gnath.}}{\text{Bizygomatic}} \times 100$	58	79–97	86.6 ± .41	4.65 ± .29	5.37 ± .34
Nasal	$\frac{\text{Nasal breadth}}{\text{Nas. to subnas.}} \times 100$	60	60–87	74.5 ± .59	6.72 ± .41	9.02 ± .56
Hand	$\frac{\text{Hand breadth}}{\text{Hand length}} \times 100$	60	34–54	42.7 ± .27	3.14 ± .19	7.35 ± .45
Foot	$\frac{\text{Foot breadth}}{\text{Foot length}} \times 100$	61	32–46	40.6 ± .23	2.71 ± .17	6.68 ± .41

Span. This measurement is difficult to accomplish on those who speak a different language from the investigator. Some try harder than others to extend themselves. In most cases, however, the writer obtained a reasonably accurate span with the assistance of a satisfactory interpreter. The results compare favorably with those of Byers.

Chest girth. Circumferential measurement of the chest is less reliable when taken over a shirt. Fortunately, at least half the men at Zaculeu could be measured without their

TABLE 3

Comparative measurements and indices on Mam-speaking Indians with probable error

	HUEHUETENANGO	JACALTENANGO	VARIOUS LOCALITIES
	Present study (1861)	Byers ('37)	d'Aloja ('23)
Age	29.7 ± 1.04	25.92 ± .77	. . .
Stature	1559.7 ± 4.72	1563.2 ± 6.2	1551.0
Span	1618.3 ± 5.90	1611.6 ± 7.4	.
Chest girth	846.1 ± 4.04	815.8 ± 4.4	843.0
Head length	182.0 ± .46	180.08 ± .66	186.73
Head breadth	143.6 ± .43	143.97 ± .44	147.30
Menton-nasion	117.6 ± .59	116.70 ± .49	117.52
Nose length	53.3 ± .42	54.65 ± .42	49.11
Nose breadth	38.3 ± .24	36.76 ± .30	37.74
Bizygomatic diameter	135.1 ± .48	130.68 ± .56	136.43
Cephalic index	78.8 ± .28	79.84 ± .35	78.90
Facial index	86.6 ± .41	89.41 ± .42	86.19
Nasal index	74.5 ± .59	67.51 ± .60	77.03

shirts. Since my mean is close to d'Aloja's but differs by 3 cm from Byers, perhaps Byers may have taken his measurements later in the day when fatigue is a factor, or on more humid days, or perhaps with a different technique.

Head shape. My figures for length and breadth of head are close to those of Byers. D'Aloja, on the other hand, obtained slightly higher figures for both dimensions. In spite of this the ratio between each set of figures, the cephalic index, is about the same.

Face shape. In both length and breadth of face, my figures are practically identical with those of d'Aloja. Byers' figures, especially for bizygomatic breadth, are lower, and as a result his facial index is higher.

Nose shape. The two dimensions of the nose and their ratios for the three series under comparison vary widely. My figure for nose length is only a little below that of Byers, but 4 mm below that of d'Aloja. My nose breadth is the highest and Byers' the lowest. Consequently my nasal index is intermediate between Byers' and d'Aloja's, which differ by 10 units. I suspect that d'Aloja has located nasion too low.

Although data on local groups are lacking for comparison with the remaining figures, certain distinctive features may be pointed out.

Strength. A body build index of 54.5 ± 0.25 is indicative of considerable robusticity. This is borne out by the brachial index of 75.3 ± 0.30 and the relative acromial breadth index of 23.7 ± 0.10. In this connection it is interesting to note that strength was diminished in and about the upper as compared with the lower extremities. The hand index of 42.7 ± 0.27 suggests reasonable strength inasmuch as it represents a hand that is not long and slender. The foot, on the other hand, is definitely strong, as is indicated by the index of 40.6 ± 0.23. Actual strength of the right hand as recorded through the use of a dynamometer averaged 22.1 kilos,[1] clearly indicating a diminished hand strength as compared with Europeans. The dynamometer was not too large for the Indians' hands. They were given the instrument to play with and to test out before the real examination took place. In this way they were taught how to use it by the interpreter and by others about them. It was easy to use this unit of measurement as a competitive factor to stimulate them in an endeavor to do their best. I feel sure it was a good measure of their strength.

[1] In a personal communication from Dra. d'Aloja the strength of the right hand in 24 Mams is given as 26.2.—Ed.

Workmen at the excavation site employed as masons, and stone workers showed a better than usual development of the hands, forearms and arms. Their robusticity raised the mean in this study. One Indian 21 years of age and of the average overall development brought in a load of lime over a 5-mile route. Upon weighing the load it was found that he had brought in 218 pounds on his back. He walked at a good clip and scarcely seemed aware of his effort at the end of his journey.

Blood pressure. According to Lutterloh ('37) changes in blood pressure, especially the systolic level, should be noted when an individual under examination is raised from a horizontal to an upright position. This should be taken into consideration also when reading the pulse. It is interesting to note that in the Mam Indians increases in systolic and diastolic blood pressures were found, but after approximately 10 to 15 minutes had elapsed, the blood pressure readings returned to those characterizing the individual in the horizontal position. My blood pressure findings are as follows:

	NO.	RANGE	MEAN
Systolic pressure	61	97.5–152.5	116.9 ± .88
Diastolic pressure	62	57 –90	72.8 ± .55
Pulse pressure	63	20 –75	43.2 ± .78

Shattuck reports a mean systolic pressure of 114.7 for 153 male Guatemalan Indians. He does not give diastolic and pulse pressures for this group.

Pulse rate. The pulse rate increased 6.89 points and remained elevated during the erect position. My results compare with those of Steggerda ('32) and Shattuck ('38) as follows:

	NO.	RANGE	MEAN	POSITION OF SUBJECT
This study	59	55–90	68.9 ± .63	Standing or sitting
Steggerda ('32)	21	40–70	60.81 ± 1.24	Sitting
Shattuck ('38)	176	?	75.1	Standing

Steggerda's low figure may reflect the considerable difference in environment between lowland and highland. Although my mean pulse rate is lower than Shattuck's, I believe that it is quite in keeping with the psychobiological make-up of the Mam group, the highland environment and the circumstances of the examination. I observed that if the pulse rate was taken early in the course of the examination it was considerably elevated, in some cases as much as 15 to 18 points. Then as soon as the individual discovered that he was not made to suffer by the examination his confidence returned, his state of tension disappeared and his pulse rate leveled off. In my opinion this is quite in keeping with the situation and seems to indicate a cardiovascular system that is functioning satisfactorily.

Respirations. The respiratory rate was counted only in the early part of the study and was found to be uniformly 18 per minute.[2] This observation was scheduled last so as to be sure that the subject was free from apprehension.

MEDICAL OBSERVATIONS

No varicose veins were observed irrespective of age. No inguinal hernia was noted, though an occasional umbilical hernia was found, but never to any considerable degree. An occasional brown pigmented mole was observed in and about the regions exposed for examination, chiefly the back, chest, and face. No signs of any chronic skin diseases were observed with one exception. This consisted of a case of impetigo of the bearded region in a young adult.

In this series there were no anomalies with the exception of a partial cleft palate and a pseudo-harelip already mentioned.

The heart of each Indian was examined by ausculation while in the erect position and no murmurs or irregularities were noted.

[2] In a personal communication from Dra. d'Aloja a respiratory rate of 19.6 is given for 24 Mams.—Ed.

Three cases of simple compensatory relatively non-toxic thyroid enlargements were noted in those examined, but not included in the metric data. In these three the pulse rate was elevated a mean of 5 with a systolic blood pressure elevation showing a mean of 8.1. The diastolic blood pressure remained constant.

The feet in this highland Indian series showed no evidence of hallux valgus. Only an occasional foot showed a greater length of second toe as compared with first toe. All feet appeared to be broad in relation to length. In those who were shoeless the sole portion was hard, showed many cracks, due to irritation by the ground surface, with an occasional infection noted, low grade in character. Toe nails were hard as compared with those of European Whites. And what interested me especially as a physician was the complete absence of any complaints of pain irrespective of how heavy the load carried or the distance walked.

OBSERVATIONS ON THE GENERAL POPULATION

These people are friendly, quiet, dignified, reserved, and shy. As might be expected of a hard working mountain people who carry their burdens either balanced on their heads, as in the female, or suspended on their backs by a forehead tump line, as in the male, posture is excellent. Muscular development in general appeared to be good to excellent. This development, however, was less than the author expected as far as the shoulder girdle and the upper extremities are concerned. Their back and neck muscles were symmetrical and of good quality, but their thighs and calf muscles were superior. Those who carried the heaviest burdens on their backs seemed to have the least upper extremity development. They frequently carried these exceedingly great weights allowing their arms to hang forward before them as a partial counterbalance, rarely placing their hands on the tump strap in the course of their carry. Occasionally they would adjust the head strap with their hands but as a rule their arms took very little of the burden. The capacity to carry enormous weights seemed

to depend upon back and lower extremity muscle power combined with balance.

Infants were carried in a sling on the hip or on the back of the mother. Occasionally a female child, approximately aged 10 to 12, would also be carrying an infant in the same manner. The female, however, was apt to carry her burdens of produce or whatnot balanced on her head, using a circular padded doughnut as a protection for her scalp.

The population of the vicinity of Huehuetenango presented a considerable number of readily recognized developmental anomalies. These consisted of 8 cases of clubfeet seen about the market places and streets of the villages. Scoliosis with or without kyphosis together with developmental disturbances such as achondroplasia and dwarfism were seen infrequently. The incidence, however, did not appear to be any greater than in the United States. No rickets was detected in any of the children. An occasional residual paralysis of poliomyelitis as well as of cerebral origin could be seen on the streets. Likewise, the incidence of these two conditions appeared to be approximately average. An obvious case of tabes dorsalis was observed in an adult male Indian. To a medical observer, this is readily recognized by type of gait.

Respiratory infections appeared to be the most common disease from which these people suffered. Practically all of the children observed in the market places, at church and on the street had a watery nasal discharge. According to the physicians in the community these respiratory infections appear to be occurring at an increased rate.

Typhus is endemic in the highland region according to Shattuck. A physician of the town of Huehuetenango told the author that the greatest number of disturbances he was called to treat were of respiratory and intestinal character. A few blind were observed on the streets. Beggars were generally victims of poliomyelitis or cerebral spastic paralyses. None was observed who seemed to show actual mental deficiency, though this is most difficult to determine. Only an occasional male Indian appeared to be under the influence

of alcohol on the road or in the market places. This included observations made on religious and civic holidays. The author is aware that this is contrary to the average impression.

I observed a number of thyroid enlargements as I passed among the people. The incidence appeared to be approximately that of the group studied (6%).

SUMMARY

Anthropometric measurements and indices, morphological and medical observations as well as photographs, are recorded for 61 male Mam-speaking highland Guatemalan Indians.

Careful selection from the Mam-speaking group was intended to supply a series for comparison with the builders of the Zaculeu pyramids and temples now under excavation and restoration by The United Fruit Company.

Pertinent medical observations and metric measurements show the male Indian to possess a mesocephalic head form, excellent robusticity, good posture and a constitution well adapted to a high rugged environment. Teeth were excellent under age 30. Beyond 30 they seemed to show a loss pattern as well as a caries incidence comparable to that of Europeans. Upper extremity strength was diminished as compared with the lower extremity strength, presumably a result of their manner of carrying burdens on their head or back. A somewhat higher pulse rate than found by other observers as well as a slightly lower pulse pressure appeared to be the case among these highland Indians.

In the general population certain disease incidence as well as the presence and kind of deformities appeared to be similar to that in the United States. Observations are reported concerning the presence of congenital deformities, poliomyelitis, cerebral palsies, respiratory infections, benign non-toxic hypertrophy of the thyroid and nutritional disturbances. Other interesting characteristics and observations are recorded.

A comparative analysis of the writer's material with the only other material published from the same region shows a reasonably close correlation in most respects with that of d'Aloja while also indicating quite a variance with data of Byers (table 3). The writer's sample is sufficiently large to add credence to data by d'Aloja.

The author wishes to acknowledge the great help extended to him by Dr. A. V. Kidder, Dr. T. Dale Stewart, Robert E. Smith, and Dr. Morris Steggerda.

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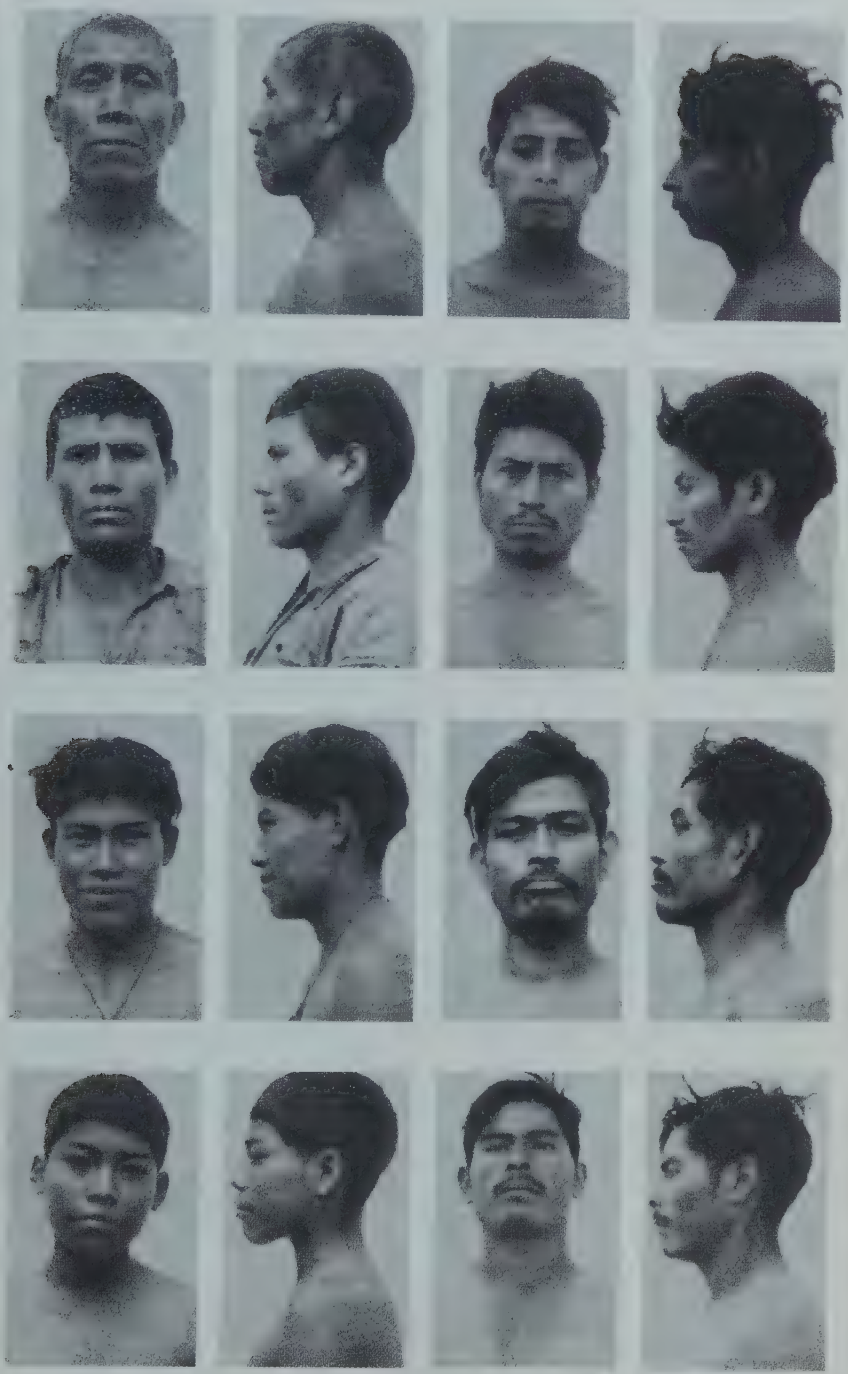
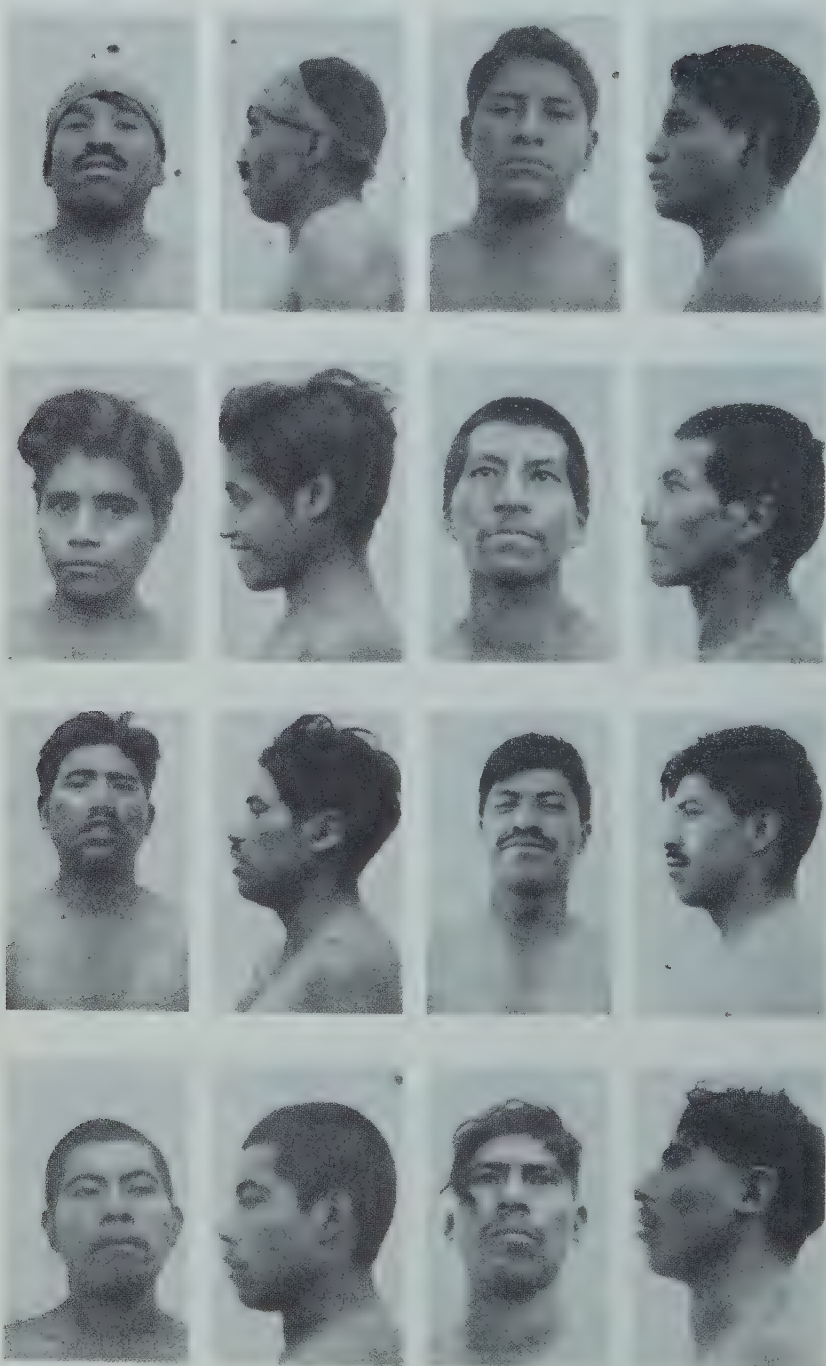
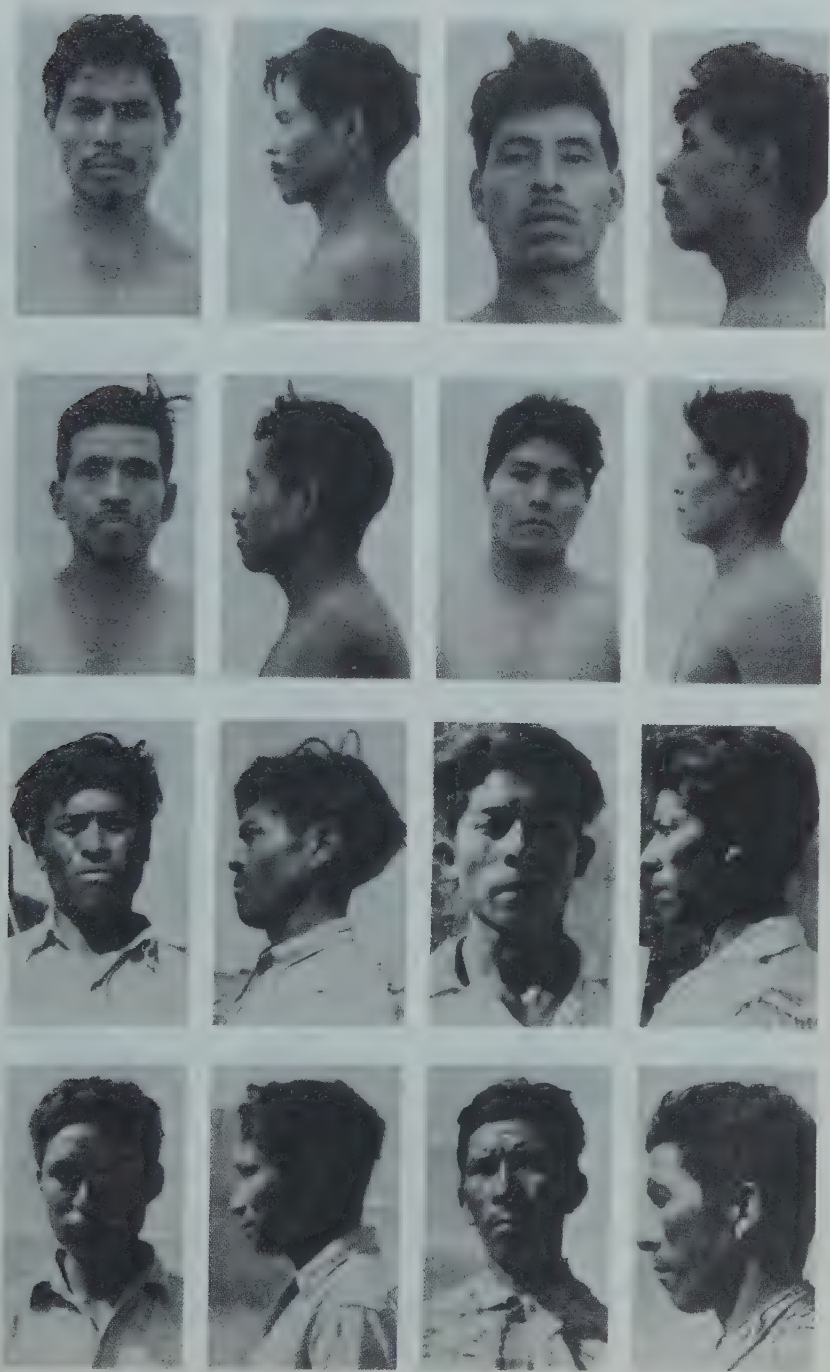
1–5 Front and side views of some of the Mam-speaking Indians included in this study.

PLATE 2







BIRTH ORDER AND BODY SIZE

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Notwithstanding the respectability which gathers with age, anthropometric techniques do not find their present users in a wholly satisfied frame of mind. Physical anthropologists have employed these techniques long and contentedly in comparative racial studies, but for one reason or another have been less eager to apply them to refined analysis of the dynamic aspects of a single population. At any rate, such an attack has not been broadly pressed. Representative exceptions, since the time of Pearson and of Boas, are the work in growth, and such studies as Hooton's ('39a, '39b) on criminals and Shapiro's ('39) on Japanese immigrants to Hawaii.

There are always present the difficulties arising from differences in details of actual technique used, leading to lack of comparability and lack of precision. Beyond this, however, general problems of approach are also hard to formulate, since the various factors affecting physical form are so difficult to control. All such factors, whether they be constitutional or environmental, when they are sought out by anthropometric methods, express themselves in the end in fluctuations in measured size, for size is the characteristic which is amenable to anthropometry. Small fluctuations in size, therefore, are the single resultant of mingled causes. Yet the individual effects of these causes — environmental, genetic, or selective — must be isolated somehow if we are to attain any advanced understanding of them through the biometric method. What is needed, therefore, is not only precision in methods of

[1] This study was supported by the Research Committee of the Graduate School, from special funds voted by the Wisconsin State Legislature.

measurement, but also a clearer idea of the aspects of physique and size which the measurements are measuring and, above all, ways of controlling the environmental and genetic factors independently.

It may be added that this would seem to be where ground might be prepared for a union with those using the purely genetical approach. These students are advancing along a line which has taken them from the contemplation of pedigrees of digital anomalies into the rich field of the genetics of populations, opening up an understanding of the exchange of genes and not merely of human mendelian traits. As this advance continues and broadens, it is likely that students conducting it will want to be provided with a more and more precise knowledge of the influence of non-genetic factors on man, and it is accordingly probable that responsibility for this knowledge will devolve upon the anthropometric approach. In other words, a guess might be hazarded that environmental factors will become more frankly the field of anthropometrists, as hereditary factors are the natural field of the geneticists.

These considerations call for special methods of research, and lead logically, as they have in the past, to the study of family lines and groups. The writer chose to investigate some of these problems through the use of brothers, measured in pairs, for the information which might be extracted from their special likenesses and differences. This paper will be primarily concerned with order of birth.

In a broad way, genetic factors by themselves should tend to produce, among the male children of a single pair of parents, a given degree of variation in the size of the body or its parts, with no special bias in the differences between different pairs of brothers. If any such bias is manifest — if, for example, earlier born children are consistently larger than later born — then this influence must be taken as environmental in nature and analyzed accordingly. Order of birth, of course, is a very gross criterion, which does not distinguish between such primarily biological factors as the changing pre-natal environment (increasing age of the mother, and possible pro-

gressive exhaustion of her reproductive system, etc.) and such primarily social factors as the declining chances for unstinted attention possessed by the later children in a family of increasing size.

Pearson, in a well known study ('14), produced evidence by an analysis of English records that first-born children were excessively prone to various diseases and pathological conditions, in the light of the expected proportion of first-born children in the given population, as Pearson reconstructed it. Other analyses (see Hogben, '31; Thurstone and Jenkins, '31) have demonstrated that stillbirths and infant mortality fluctuate with birth order and age of mother, with indications that the latter factor is the ruling one, and also that related social factors are by no means fully controlled in these matters. One of the most striking of these "environmental" effects is the well-attested relationship between the incidence of Mongolian idiocy and both later age of mother and higher order of birth within the family.

As a possible indicator of the force of such effects, adult body size in its relation to birth order has hardly been investigated at all. Boas (1895) made a start by comparing the relative size of growing children at different ages. Using children of Oakland, California, in one-year age groups from the age 6–7 on, he took the mean difference for each birth order, within each age group, from the average for that age group. This made it possible in a rough way to eliminate age, and to strike an average deviation from the mean for different birth orders covering all boys between the ages of 6–7 and 16–17, and girls from 6–7 to over 18. These average deviations favor the earlier born as follows (these are the *mean* differences from the average of each age class):

Stature, in millimeters

	1ST BORN	2ND BORN	3RD BORN	4TH BORN	LATER BORN
Boys	+ 4.5	+ 4.0	+ 1.9	— 7.9	— 6.9
Girls	+ 7.1	— 2.8	— 4.5	— 3.3	— 2.3

Weight, in pounds

	1ST BORN	2ND BORN	3RD BORN	4TH BORN	LATER BORN
Boys	+ .82	+ .60	+ .32	— 1.58	— .44
Girls	+ 1.12	+ .48	— 1.71	— .72	— .12

In Boas' full table the separate age classes show various inversions of the progression shown in the average of all, but Boas felt that on the whole there was such regularity in the figures favoring the earlier born that there could be no doubt as to the reality of this phenomenon, at least in sub-adult years.

Pearson's material ('03) on brothers and sisters [2] (presumably all adults) gives the advantage to the younger members rather than the older; this is slight, however, and statistically negligible, and cannot be taken as any reliable indication in the matter. Actual birth order is not referred to in these data; the individuals are simply taken by pairs, and series of elder and younger siblings derived accordingly:

	NUMBER	MEAN	S.D.	MEAN	S.D.
		Older brothers		Younger brothers	
Stature	328	174.78 ± .25	6.60	174.93 ± .26	7.01
Span	324	178.36 ± .26	6.88	178.38 ± .30	7.98
Elbow–fingertip	322	47.17 ± .09	2.41	47.14 ± .09	2.39
		Older sisters		Younger sisters	
Stature	473	162.22 ± .21	6.88	162.61 ± .20	6.60
Span	481	161.15 ± .24	7.64	161.74 ± .23	7.52
Elbow–fingertip	473	42.51 ± .07	2.27	42.68 ± .06	1.79

Bowles ('32) found a similar effect by using records on Harvard students made by the Sargent system, and taking what pairs of brothers he could find therein. Of 30 measurements used, the younger brothers were on the average larger in all cases, excepting only in breadth of head and breadth of waist. Again, however, the excess was not great, and according to the writer's calculations would approximate or exceed three times its probable error only in 4 measurements: girth of waist, girth of upper arm, girth of elbows, and breadth of hips; not an impressive group of characters, given the excess of weight of the younger brothers to begin with. A selection of the figures given by Bowles is shown in table 1. Bowles concluded, taking his own and Boas' results, that younger children of a family mature more slowly than the older, but

[2] The figures given here were calculated by the writer from Pearson's tables lviii–lxiii.

in the end catch up with the latter and surpass them. The writer's data, however, do not corroborate this, and give a sampling in which the older brothers are somewhat larger in size than the younger.

TABLE 1

Mean measurements for Harvard students, from Bowles ('32)

	NUMBERS	OLDER BROTHERS	YOUNGER BROTHERS
Weight	79	148.20 ± 1.11	152.45 ± 1.14
Stature	79	176.82 ± .44	177.96 ± .40
Sitting height	79	91.60 ± .28	91.98 ± .24
Girth of waist	79	73.30 ± .31	74.64 ± .33
Girth of hips	79	91.14 ± .29	91.98 ± .30
Girth of chest (N)	78	89.62 ± .38	89.96 ± .33
Girth of chest (F)	79	94.48 ± .35	95.22 ± .33
Girth of head	79	56.98 ± .12	57.00 ± .12
Girth of upper arm	79	29.67 ± .16	30.36 ± .17
Girth of elbow	75	24.28 ± .10	24.91 ± .10
Girth of forearm	79	26.49 ± .10	26.85 ± .12
Girth of wrist	79	16.47 ± .05	16.55 ± .05
Breadth of head	66	14.90 ± .05	14.84 ± .06
Breadth of shoulders	79	42.75 ± .17	43.34 ± .16
Breadth of waist	78	25.37 ± .15	25.33 ± .12
Breadth of hips	79	32.01 ± .11	32.54 ± .13
Shoulder–elbow length	79	36.44 ± .14	36.49 ± .12
Elbow–finger length	79	47.30 ± .15	47.56 ± .13
Foot length	78	25.80 ± .09	25.90 ± .08
Span	78	181.93 ± .52	183.01 ± .49

This sample was drawn from the student body of the University of Wisconsin in 1941 and 1942.[3] A principal aim was to use a standard schedule of anthropometric measurements

[3] The measuring was all done by Dr. Earle L. Reynolds, now of the Fels Institute, Yellow Springs, Ohio. Statistical work was done both by Mr. Neil C. Tappen and by Dr. Richard L. Hornseth, and I owe the latter thanks for valuable statistical advice as well.

for the purpose, since Bowles had had to fall back on Sargent's measurements, consisting of girths and breadths less closely related to skeletal form. In order to reduce the hazards both of technique and of diurnal variation in stature and sitting height, the brothers were measured together and at the same time. Almost all were found as couples, with only 4 families yielding three brothers. In the case of these, all possible pairs of older and younger brothers were made, so that in these few cases an individual will appear twice in the same series, or else as both an older and a younger brother.

Table 2 compares older and younger brothers as such, in mean measurements. (Stature and sitting height appear in centimeters; all other measures in millimeters.) It may be said that none of the differences exceeds three times the probable error, excepting sitting height, which barely does so (and at least one such difference might be expected by chance among the comparisons made here), and ear length, where the difference is over 4.5 times the probable error. This may be an actual age difference. As for the rest, however, considering these and older data, it would appear that no such comparison of older and younger brothers, pure and simple, seems likely to give consistent differences. Certainly the differences found in this case are not to be relied upon.

As far as they go, they make the older brothers larger in a majority of the measurements. Such differences are most pronounced (excepting ear length) in stature, and especially in sitting height — this is more marked percentagewise than in limb lengths. Other differences, especially in measurements of the head, are minor. There is, of course, a mean age difference of about three years between the groups, something not present in Bowles' comparison, since the Harvard brothers were measured individually on their arrival in college, rather than at the same time. However, a breakdown by age of both the older and the younger brother series in several of the measurements (the results are not shown here) did not indicate an age trend or biasing which would explain the general results.

TABLE 2

Mean measurements of Wisconsin brothers

	OLDER BROTHERS			YOUNGER BROTHERS			ALL BROTHERS		
	N	M	S.D.	N	M	S.D.	N	M	S.D.
Stature	94	177.74 ± .45	6.50	95	176.17 ± .39	5.63	180	176.92 ± .31	6.24
Sitting height	95	91.90 ± .23	3.30	95	90.97 ± .19	2.76	181	91.43 ± .16	3.22
Biacromial	97	396.35 ± 1.12	16.40	97	393.75 ± 1.32	19.26	182	395.27 ± .92	18.34
Bi-iliac	97	299.30 ± 1.06	15.51	97	297.78 ± 1.02	14.89	182	298.42 ± .75	14.97
Upper arm length	94	336.76 ± 1.24	17.76	97	333.40 ± 1.13	16.48	179	334.73 ± .87	17.16
Length of radius	94	265.06 ± .94	13.55	96	263.69 ± .80	11.60	178	264.48 ± .65	12.85
Length of tibia	95	398.50 ± 1.54	22.26	96	398.77 ± 1.45	21.10	179	398.47 ± 1.11	21.96
Head circumference	96	569.49 ± 1.01	14.69	97	568.56 ± 1.01	14.70	181	568.96 ± .74	14.80
Head length	96	196.28 ± .43	6.27	97	195.54 ± .45	6.56	181	195.79 ± .32	6.47
Head breadth	97	154.26 ± .39	5.73	97	154.32 ± .34	5.01	182	154.42 ± .27	5.39
Head height	95	126.01 ± .44	6.38	96	126.41 ± .42	6.12	179	126.19 ± .32	6.26
Minimum frontal	97	105.08 ± .32	4.60	97	105.45 ± .32	4.74	182	105.05 ± .22	4.44
Bizygomatic	97	139.02 ± .32	4.70	96	137.88 ± .32	4.66	181	138.37 ± .24	4.76
Bigonial	96	105.28 ± .41	5.94	95	104.46 ± .34	4.98	179	104.82 ± .27	5.36
Face height	95	127.97 ± .50	7.16	96	127.38 ± .49	7.19	179	127.42 ± .36	7.15
Upper face height	97	77.76 ± .37	5.39	97	78.13 ± .37	5.34	182	77.84 ± .27	5.37
Nose height	97	59.54 ± .29	4.17	97	59.36 ± .31	4.55	182	59.41 ± .22	4.34
Nose breadth	96	35.90 ± .17	2.53	97	36.32 ± .15	2.26	181	36.15 ± .12	2.41
Ear length	96	64.77 ± .22	3.16	97	63.74 ± .23	3.32	181	64.21 ± .16	3.26
Ear breadth	97	36.58 ± .15	2.18	97	36.75 ± .15	2.17	182	36.72 ± .10	2.09

The above comparison simply makes use of all brothers, irrespective of actual order of birth or other matters. A more precise comparison is made in table 3, in which contiguous brothers are taken in pairs, and the mean difference between the individuals is shown by birth order. The orders are actual order of birth, not simply order of brothers. Unfortunately the numbers available are small. There is a certain consistency of pattern in some measurements, e.g. stature and sitting height, which favor the elder brothers. Limb lengths are variable. There is slightly more consistency among the measurements of the head than appears in the general comparison of older and younger brothers (table 2), and here again it is a matter of the elder brother being favored, when he is first- or second-born. In general, elder brothers are favored in these pair comparisons in about the same majority as before.

TABLE 3

	AVERAGE EXCESS IN MILLIMETERS, BY PAIRED BROTHERS, OF			
	1st born over 2nd	2nd born over 3rd	3rd born over 4th	All elder brothers
Stature	3.04 (46)	18.93 (14)	14.00 (8)	12.32 (92)
Sitting height	5.17 (46)	7.73 (15)	7.44 (9)	6.63 (94)
Biacromial	.89 (46)	1.75 (16)	9.89 (9)	2.46 (96)
Bi-iliac	.37 (46)	2.56 (16)	— .89 (9)	1.50 (96)
Upper arm length	2.00 (45)	—2.12 (16)	7.56 (9)	2.46 (94)
Length of radius	— .22 (46)	2.25 (16)	2.67 (9)	1.31 (96)
Length of tibia	—1.93 (46)	1.53 (15)	—4.86 (7)	— .63 (93)
Head circumference	1.00 (46)	3.80 (15)	—2.11 (9)	.65 (95)
Head length	.58 (45)	2.12 (16)	—1.67 (9)	.91 (95)
Head breadth	.30 (46)	.93 (16)	.44 (9)	— .15 (96)
Head height	— .63 (46)	—2.06 (16)	.67 (9)	— .60 (96)
Minimum frontal	— .22 (46)	—1.00 (16)	.44 (9)	— .47 (96)
Bizygomatic	1.57 (46)	.44 (16)	2.00 (9)	1.14 (96)
Bigonial	1.07 (46)	.81 (16)	1.38 (8)	.73 (94)
Face height	.24 (46)	.56 (16)	—1.00 (9)	.53 (96)
Upper face height	— .07 (46)	1.44 (16)	—2.67 (9)	— .11 (96)
Nose height	— .17 (46)	— .19 (16)	.56 (9)	.08 (96)
Nose breadth	.11 (45)	— .25 (15)	.22 (9)	— .28 (95)
Ear length	.63 (46)	1.56 (16)	1.44 (9)	.98 (96)
Ear breadth	— .46 (46)	— .25 (16)	.56 (9)	— .24 (96)

The above material suggests another aspect of the differentiation of brothers: their differing degrees of likeness or difference in differnt measurements. Pearson ('03) provided coefficients of correlation on adult brothers and sisters as follows:

	Brothers		Sisters	
	N	r	N	r
Stature	328	$.511 \pm .028$	473	$.537 \pm .022$
Span	324	$.549 \pm .026$	481	$.555 \pm .021$
Elbow–fingertip	322	$.491 \pm .029$	473	$.507 \pm .023$

For between 1000 and 2000 pairs of brothers of school age, he found:

	r
Cephalic index	.486
Head length	.504
Head breadth	.593
Auricular height	.554

From these data and a few on eye color, etc., Pearson concluded that "the degree of resemblance of brethren is closely the same for all characters," and that "the intensity of fraternal correlation in man is close to .5." These things do not appear to be true, something which will be treated more fully in a subsequent paper. Bowles found from the Harvard records on paired brothers that heights and lengths had r's approximating .50, but that r's for girths averaged .35, and those from breadths .25.

This kind of difference would appear to be a significant fact in the patterning of human growth. It is to be found also in the r's for the brothers described in the present paper, these coefficients being given in table 4. It may be seen here that the same characters which Pearson used give r's largely in the vicinity of .5, as he found, while transverse diameters, with the principal exceptions of head breadth, minimum frontal diameter, and biacromial breadth, are fraternally correlated to a distinctly lesser degree. Bowles' "breadth of shoulder" (shown in table 4 opposite "biacromial"), it may be noted, is low. Sitting height, among all longitudinal measurements, gives a low coefficient; Bowles found it below stature but not as low as in the Wisconsin brothers.

The present material on brothers, unfortunately too limited for further analysis, is more suggestive than revealing. For one thing, it strongly indicates that a representative schedule of measurements must be used in such studies, instead of the limited group — stature and one or two head or body diameters — relied on in the older work of Boas, Pearson and

TABLE 4

Coefficients of correlation between brother pairs

	WISCONSIN BROTHERS		HARVARD BROTHERS (BOWLES, '32)	
	N	r	N	r
Weight			79	.55 ± .05
Stature	94	.473 ± .054	79	.57 ± .05
Sitting height	95	.349 ± .061	79	.46 ± .06
Biacromial	97	.447 ± .055	79	.22 ± .07
Bi-iliac	97	.358 ± .060		
Upper arm length	94	.427 ± .057	79	.60 ± .05
Length of radius	95	.516 ± .051		
Length of tibia	94	.584 ± .046		
Head circumference	92	.422 ± .058	79	.50 ± .06
Head length	94	.384 ± .059		
Head breadth	94	.484 ± .053	66	.29 ± .08
Head height	90	.492 ± .054		
Minimum frontal	94	.474 ± .054		
Bizygomatic	96	.272 ± .064		
Bigonial	92	.303 ± .064		
Face height	94	.590 ± .045		
Upper face height	94	.507 ± .052		
Nose height	94	.511 ± .051		
Nose breadth	93	.251 ± .066		
Ear length	94	.277 ± .064		
Ear breadth	94	.216 ± .066		

others. Shapiro's study has already demonstrated the fact. Granting this, however, physical anthropologists have all too vague an idea of the quantities through which they are working. If we are going to proceed with anthropometry, we absolutely must know more about the things it is measuring; we are now, so to speak, trying to read it without knowing its grammar. There has been a tendency, for example, to use

stature as a yardstick in discussing secular changes in physical type, or in comparing socio-economic groups physically. Is stature adequate for this? Does it faithfully reflect the changes taking place in the body as a whole, as a measure of general increase in size? Such studies as those of Bowles ('32), Shapiro ('39), and Goldstein ('43) show clearly that this is not so, and that whole patterns of body changes are involved, a tracing of which might finally tell a great deal about the nature of human growth and plasticity of type.

SUMMARY

1. If birth order, taken alone, has any constant influence on adult body form, this has yet to be demonstrated. Bowles found indications that among Harvard brothers of a generation or so ago the younger brothers had a constant size advantage, quite apart from the secular increase in stature. In the present sample, when Wisconsin brothers were compared simply as series of "older" and "younger," no corroboration of Bowles' results was found. There was an advantage for the older brothers, especially in body and limb lengths, of a degree too slight to be reliable. A more careful comparison, by actual pair differences according to birth orders, was no more revealing.

2. Fraternal coefficients of correlation differ considerably in different measurements, with longitudinal measurements generally showing a stronger correlation between brothers than measurements of breadth.

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VIEWS ON THE INHERITANCE OF SKIN COLOR.— In a letter to the Editor of *The Journal of Heredity* (vol. 39, 1948, pp. 232–234) describing a so-called "black baby" R. Ruggles Gates concludes:

"The current theory of skin color inheritance requires revision. A work now in press [Genetics of Negro Families] will show that the skin color factors are not only cumulative but unequal in effect. It is evident that some children of colored couples should be darker and some lighter than either parent. Colored families themselves say that some of their children have a darker skin than either parent. But the present observations suggest that other characters than skin color have played a part in producing the wide-spread impression of a 'black baby.' "

To this the Editor replies:

"As pointed out by Stern (J. Hered., vol. 38, 1947, pp. 233–234), the present genetic concept of inheritance of human color differences assumes that there are at least two pairs of alleles, cumulative in their effects. This means that if a child is blacker than either parent the genes for heavy pigmentation must be carried by both parents, so that the number of "plus genes" can be increased in the child. Hence this case, even if taken at face value seems wholly inadequate to require that 'the current theory of skin color inheritance requires revision.' "

THE CRANIOFACIAL MORPHOLOGY OF MANDIBULAR RETRUSION

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THREE FIGURES

INTRODUCTION

This is a study of the craniofacial morphology of mandibular retrusion, a dentofacial anomaly commonly found in the American population. Various methods of classification and description of malocclusions have been devised by orthodontists; we shall adhere to the one most commonly used, that of Angle (1899), and have limited the investigation to Angle's Class II, division 1, which is defined as a posterior relationship of the mandibular jaw and dental arch to the maxillary structures, with protruding maxillary anterior teeth. (Angle also describes Class II, division 2, wherein the maxillary anterior teeth are retruded, but no cases of this division have been included in this study.) Figure 1 shows the face of a typical mandibular retrusion of the variety investigated here, with the receding chin, the deep fold beneath the lower lip, the upward curl of the upper lip, the habitually open mouth, and the protrusion of the maxillary anterior teeth. The plaster models (fig. 2) show that the mandibular teeth occlude with the maxillary teeth in a posterior relationship by the width of one premolar. Maxillary and mandibular dental arches are narrow, and the mandibular incisors frequently strike the tissues of the hard palate behind the maxillary incisors. The maxillary anteriors are spaced and flare forward; they cover

completely the mandibular incisors when the jaws are closed because of the typical overclosure in cases of this class.

The possible morphological variations which might give rise to this anomaly are these: maxillary bones which are anteriorly situated with respect to other facial structures, carrying with them the maxillary dental arch. Secondly,

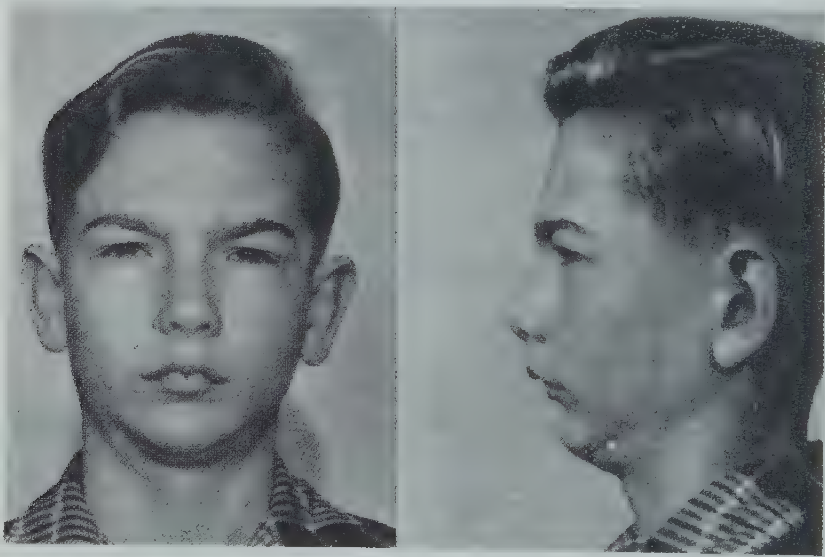

Fig. 1 Typical face accompanying Class II, division 1 malocclusion.

Fig. 2 Dental relationships in Class II, division 1 malocclusion.

the maxillary bones might be within limits of tolerable variation, with the maxillary dental arch anteriorly placed on those bones. Thirdly, the mandible might be underdeveloped with relation to other facial structures, or it might be average in size but for some reason posteriorly placed with respect to other facial structures. There is the possibility that both maxilla and mandible are average with respect to size and anteroposterior position, and that the mandibular dental arch is posteriorly placed on the mandibular base. This is unlikely, since the chin is obviously retrusive in most of these cases.

Most of the writing on the subject of mandibular retrusion has been in the specialty journals of dentistry and has dealt with therapy or with presumed etiological factors, with little supporting evidence offered. A few studies have been made with direct measurements upon the living or upon the skulls, but paucity of material or unsatisfactory se'ection of landmarks from which to measure have lessened their value.

Investigations with the Broadbent-Bolton cephalometer ('31) have some bearing on this problem. Brodie ('41) showed a constancy of facial proportions from the third month to the 8th year of life, thereby establishing that in facial patterns predisposing to mandibular retrusion, the basis is present from birth and cannot be attributed to some postnatal cause. Baldridge ('41) studied the possibility that the primary basis of this anomaly is an anterior position of either the maxilla or the maxillary dental arch by making a statistical comparison of a group of Class II malocclusions with a group of individuals who had irregularity of the teeth but no abnormal anteroposterior relationship of the dental arches (Class I). Using oriented lateral headfilms, he measured the angle formed by connecting nasion-sella-maxillary first permanent molar, and found no significant difference between the means of the two groups studied. He did find that the angle nasion-sella-gnathion was larger in a group of Class II, division 1 individuals than it was in a group of Class I, thereby establishing that the chin-point was farther posterior in the group

having the anomalous dental arch relationship. Elman ('40) investigated the possibility that the mandibular dental arch was situated in a significantly different fashion on the mandibular base in this anomaly by measuring the distance from the mandibular first permanent molar back to the posterior border of the ramus, and the distance from the same point on the mandibular first permanent molar perpendicularly to a line tangent to the lower border of the mandible. He found that these two distances were in the ratio of approximately three to two in both classes of malocclusion. Accordingly, no significant difference was established. Adams ('39) in an unpublished report showed no significant difference in form or size between the mandibles of the two classes under consideration. Brodie ('43), under whose supervision these studies were conducted, then raised the possibility that the primary basis for the anomaly might be situated in the floor of the cranium, arguing that since the maxillary structures are associated with the anterior cranial base while the glenoid fossa of the temporal bone is situated in the medial cranial base, that unusual length in the floor of the cranium might produce a sufficient disharmony in the position of these structures to produce the anomaly of occlusion described. Such an hypothesis seemed justified, since no significant difference in facial structures had been established.

This work undertakes to test this hypothesis and to study some of the morphological aspects of the anomaly in greater detail.

MATERIAL AND METHODS

Oriented lateral headfilms of 48 females (ages 5–23) and 45 males (ages 5–16) having clear-cut Class II, division 1 malocclusions were taken prior to orthodontic treatment. No cases were selected which merely had "Class II tendencies," had the anomaly unilaterally, or were in any other respect not entitled to be considered classical examples of Class II, division 1 malocclusion. For each of these individuals, films taken on a person of the same sex and age (to nearest birth-

day) were chosen from those having Class I malocclusion (normal anteroposterior jaw relationship). The subjects were white San Francisco school children, drawn from different socio-economic levels. The exact matching of the two groups with respect to sex and age was considered necessary, since cranial dimensions attain adult values at a much earlier age than do facial dimensions, and merely matching mean ages might have introduced misleading data. All measurements were taken on tracings of lateral headfilms showing the teeth in centric occlusion (inclined planes of occlusal surfaces in full closure), except maximum head length and maximum head breadth which were taken with calipers on the living subject in the conventional fashion. In the Broadbent-Bolton technique, enlargement of structures due to x-ray distortion is minimized by a long target distance and consequently the slight remaining size distortion was ignored in the study, since it may be assumed that neither sample was affected more than the other. The following measurements (see fig. 3) were taken on each tracing:

1. Nasion-Bolton (N–B). The point Bolton (Broadbent, '31) is situated on the highest point on the notch behind the occipital condyles. Basion would be a preferable point, but it is not seen in the x-rays.

2. N–C. The line N–B is divided in two parts by projecting the center of the head of the condyle to the line N–B. The anterior portion is designated N–C, and is called the hafting zone, since it is in this area that the face is hafted from the cranium. If the length of the cranial base is actually a primary factor in this anomaly, N–C, and probably N–B, should be significantly longer in Class II, division 1 than in Class I.

3. N–C (rest position). This measurement is essentially the same as the above, except that it was determined for each individual on additional films taken when the jaws were in the rest position, i.e., not in centric occlusion but with the teeth parted slightly, which is the normal rest relationship of the jaws. It tests the hypothesis held by

some orthodontists that the malrelation of the jaws in centric occlusion is due to a mechanical deflection of the mandible posteriorly by the deep overbite. If this were true, one could expect to find that the distance N–C would be significantly greater in the centric position in the Class II, division 1 samples as compared with the same distance measured in the rest position.

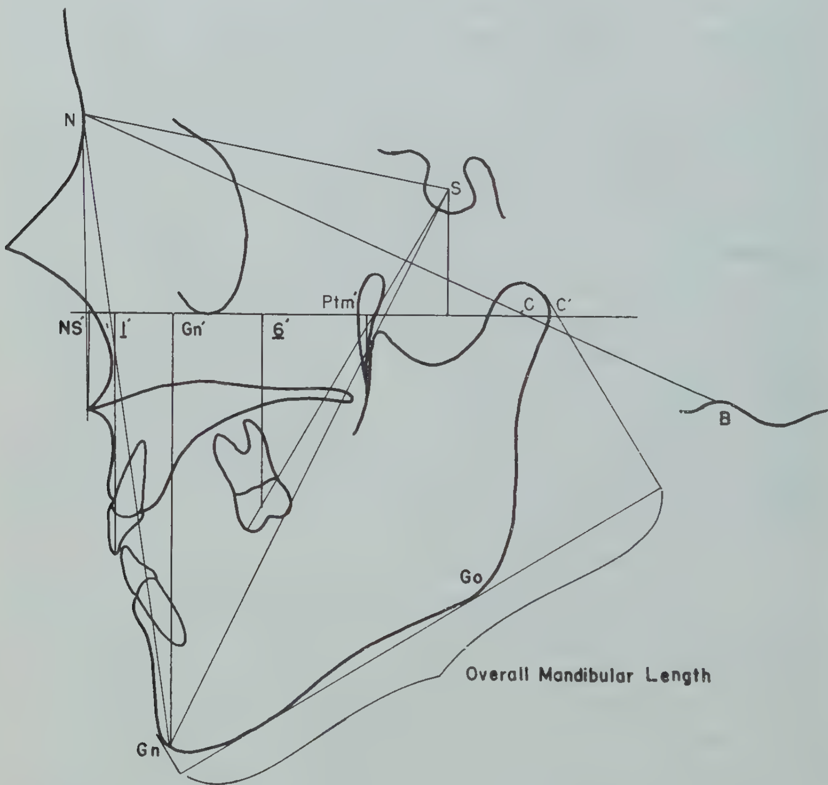

Fig. 3 Points of measurement taken from lateral cephalometric films.

4. Overall mandibular length. A line tangent to the lower border of the mandible was drawn, and perpendiculars from the most posterior point on the head of the condyle and from gnathion were dropped to this line. The distance between these two projected points was designated overall

mandibular length. This measurement is affected not only by the size of the lower border and the ramus of the mandible, but by the magnitude of the gonial angle as well.

5. Go–Gn. The distance between gonion and gnathion.

PROJECTIONS TO FRANKFORT HORIZONTAL PLANE

The following points were projected to the Frankfort plane: C, the most posterior point on the head of the condyle; S, center of sella-turcica; Ptm, pterygomaxillary fissure; *6*, buccal groove of the maxillary first permanent molar; Gn, gnathion; *1*, the incisal edge of the maxillary central incisor; NS, anterior nasal spine. The "prime" indicates projections of these points to the Frankfort plane, rather than the actual points themselves, wherever the symbol appears.

Distances between these various points were measured as follows:

C′–S′. This distance between the condyle and the center of sella-turcica, as measured along the Frankfort plane, includes the area of the spheno-occipital junction, a cranial growth site, and tests the possibility that there is a local elongation in this area in Class II, division 1 malocclusions.

S′–Ptm′. If the hypothetical elongation lies immediately posterior to the maxillary bones, this measurement discloses the fact.

Ptm′–NS′. A measure of overall maxillary length.

Ptm′–*6*′. A measure of the anteroposterior placement of the maxillary first permanent molar on the maxillary base.

S′–*6*′. Locates the same tooth anteroposteriorly with respect to a cranial landmark.

S′–Gn′. A measure of the anteroposterior placement of the chin-point with respect to the same cranial landmark.

S′–1′. A measure of the anteroposterior placement of the maxillary central incisors with respect to the cranial landmark.

S′–NS′. A measure of the anteroposterior placement of the most anterior point on the maxilla with relation to the cranial landmark.

ANGLES

N–S–*6*. This applies the method of Baldridge in determining the anteroposterior placement of the maxillary first permanent molar.

N–S–Gn. Repeating Baldridge's method, this time with males and females in separate samples.

S–N–Gn. Using the previously mentioned angle as a measure of chin position is open to criticism, since this angle may be decreased not only by a relatively anterior position of the chin, but also by decrease in the vertical height of the face. The angle S–N–Gn was accordingly added to the study, since it is more indicative of anteroposterior position alone.

S–N–NS. An angular measurement of the anteroposterior placement of the anterior nasal spine.

TABLE 1

Mean values of dimensions measured

VARIATES	CL. I FEMALES n = 48	CL. II–1 FEMALES n = 48	CL. I MALES n = 45	CL. II–1 MALES n = 45
Age (yrs.)	11.33 ± 0.42	11.33 ± 0.42	11.51 ± 0.37	11.51 ± 0.37
N–B (mm)	122.53 ± 0.79	122.94 ± 0.71	127.67 ± 0.88	128.31 ± 0.75
N–C	84.40 ± 0.74	86.04 ± 0.61	89.00 ± 0.70	89.31 ± 0.68
C′–S′	16.65 ± 0.55	17.23 ± 0.46	18.27 ± 0.47	18.31 ± 0.44
S′–Ptm′	17.21 ± 0.39	17.69 ± 0.37	18.02 ± 0.36	18.07 ± 0.34
Ptm′–NS′	51.90 ± 0.47	52.25 ± 0.44	52.28 ± 0.47	55.33 ± 0.52
Ptm′–*6*′	15.71 ± 0.48	15.94 ± 0.51	14.91 ± 0.46	16.60 ± 0.56
S′–*6*′	32.94 ± 0.68	33.79 ± 0.73	32.98 ± 0.63	34.62 ± 0.73
S′–Gn′	54.35 ± 1.08	52.38 ± 1.06	54.42 ± 0.97	53.58 ± 1.10
S′–*1*′	68.58 ± 0.71	70.83 ± 0.86	68.96 ± 0.74	73.89 ± 0.87
S′–NS′	69.00 ± 0.59	69.92 ± 0.62	70.51 ± 0.59	73.11 ± 0.60
Go–Gn	68.38 ± 0.76	65.98 ± 0.82	68.04 ± 0.84	67.29 ± 0.78
Overall mandibular length	100.96 ± 1.02	97.06 ± 1.04	102.93 ± 1.28	100.56 ± 0.90
Gonial angle (degrees)	120.00 ± 1.00	120.14 ± 0.93	120.56 ± 0.96	121.11 ± 1.08
Angle N–S–Gn	68.81 ± 0.45	69.48 ± 0.55	69.13 ± 0.51	69.58 ± 0.55
Angle N–S–*6*	66.90 ± 0.44	66.77 ± 0.56	67.09 ± 0.50	66.98 ± 0.51
Angle S–N–Gn	76.35 ± 0.53	74.31 ± 0.45	75.62 ± 0.49	74.44 ± 0.52
Angle S–N–NS	85.29 ± 0.59	85.08 ± 0.50	84.47 ± 0.62	86.60 ± 0.55
Cephalic index	79.28 ± 0.58	78.85 ± 0.46	79.82 ± 0.65	78.14 ± 0.54
Head breadth (mm)	144.62 ± 0.79	142.65 ± 0.81	148.68 ± 0.73	145.20 ± 0.77
Head length	182.52 ± 0.92	180.89 ± 0.84	186.48 ± 1.18	185.93 ± 0.93

FINDINGS

Table 1 shows the means for each of the dimensions in each of the samples studied. Wherever a significant difference between the two sexes in one class of malocclusion was found, that difference was entered in table 2 with the ratio of the difference to the standard error of difference indicated. In similar fashion, differences based on the occlusion of the teeth are listed in table 3.

TABLE 2

Significant differences between sexes

DIMENSION	CLASS I		CLASS II, DIV. 1	
	M ♂–M ♀	$\frac{\text{Difference}}{\sigma \text{ Diff.}}$	M ♂–M ♀	$\frac{\text{Difference}}{\sigma \text{ Diff.}}$
N–B	5.1 mm	4.35	5.4	5.23
N–C	4.6	4.51	3.3	3.57
C′–S′	1.6	2.24	. .	. . .
Ptm′–NS′	. .	. . .	3.1	4.54
S′–*1*′	. .	. . .	3.1	2.50
S′–NS′	. .	. . .	3.2	3.70
Overall mandibular length	. .	. . .	3.5	2.54
S–N–NS	. .	. . .	1.5°	2.03
Head breadth	4.1	3.78	2.6 mm	2.28
Head length	4.0	2.64	5.0	4.00

TABLE 3

Significant differences between classes of malocclusion

DIMENSION	MALES		FEMALES	
	M_{II-1}–M_I	$\frac{\text{Difference}}{\sigma \text{ Diff.}}$	M_{II-1}–M_I	$\frac{\text{Difference}}{\sigma \text{ Diff.}}$
Ptm′–NS′	3.1 mm	4.39	. .	. . .
Ptm′–*6*′	1.7	2.35	. .	. . .
S′–*1*′	4.9	4.32	2.2	2.02
S′–NS′	2.6	3.08	. .	. . .
Overall mandibular length	. .	. . .	— 3.9 [1]	2.67
Angle S–N–Gn	. .	. . .	— 2.0°	2.93
Angle S–N–NS	2.1°	2.58	. .	. . .
Cephalic index	— 1.7	1.99	.	. . .
Head breadth	— 3.5 mm	3.30	. .	. . .

[1] Minus sign indicates that larger value is that of class I.

The dimension N–C (rest position) will not be found in any of the tables, since an evaluation of the data carried out when there were approximately 30 cases in each sample showed that this measurement would do nothing to elucidate the problem. This measurement, involving as it did an additional film for each subject, was not included in the material measured subsequent to the preliminary examination.

DISCUSSION

The only logical conclusion at which one can arrive after studying these data is that the abnormal dental arch relationship observed in Class II, division 1 malocclusions is dictated primarily by a dysplastic relationship between the maxillary and the mandibular jaws, and that no single portion of the craniofacial anatomy may be singled out as being the anomalous part in every instance of this malocclusion. Although it is quite obvious, statistically speaking, that the anatomical basis is essentially different in males from that found in females, it would be gross oversimplification to say that the malocclusion is uniformly mandibular retrusion in females and maxillary protrusion in males.

In the first place, the size of the differences observed between means of Class II, division 1 and Class I samples, regardless of statistical significance, is in no case large enough to provide a single explanation for the anomaly. It should be remembered that the anteroposterior discrepancy in the dental arches is approximately 7 mm, i.e., the width of the average premolar. Secondly, an analysis of individual data cards shows that factors of basic facial pattern interact with one another to influence the occlusion of the teeth; two variables may tend to reinforce one another to produce a retrusive effect, or, on the other hand, may cancel one another out to give a normal anteroposterior dental arch relationship.

Any consideration of anomalies of anteroposterior dental arch relationship must be based on the fact that while the dimensions of underlying facial structures are certainly continuous variables, the occlusion of the teeth, for mechanical

reasons, may be considered a discontinuous variable. When maxillary and mandibular teeth meet in erupting to the occlusal plane, there is an interdigitation of cusps which in continued mastication tends to make the opposing teeth settle into one another. The adjustments necessary for this settling take place in the alveolar bone which supports the teeth, permitting their ultimate meshing into a relatively precise relationship. It is also probable that some of this adjustment takes place in the temporomandibular joint. Furthermore, this mechanical interlocking virtually guarantees that the inclined planes which meet each other for the first time will remain in contact, so that two different individuals with almost identical basic facial patterns which would predispose to a point-to-point initial contact of cusps, might ultimately look very different from one another in centric occlusion if different inclined planes met, guiding the teeth into different fossae. In the instance given, two individuals differing little in the measurements described here would fall into different samples when selection is based on occlusion alone. On the other hand, we might well find in the same sample basically different patterns which have been "guided" into the same Angle classification by cuspal interdigitation.

Even limited experience in examining parents and siblings of patients having this type of malocclusion leads one to suspect that inheritance might play a part in establishing the anomaly, in spite of the fact that orthodontic textbooks have in the past given that aspect of its etiology short shrift. Our finding that the malocclusion is, statistically speaking, basically different in males and females makes the older explanations based entirely on local factors difficult to accept. It also stimulates speculation as to the mode of inheritance, speculation which should not go unchecked until the same methods of measurements are applied to samples consisting entirely of prepuberal material.

The demonstration that the cephalic index of the Class II, division 1 males is less than that of Class I males, assuming that a ratio of difference to standard error of difference of

1.99 may be considered to border upon statistical significance, would at first seem quite reasonable since it has been otherwise demonstrated that maxillary structures tend to be longer in males having this anomaly of occlusion. However, separate consideration of head length and head breadth shows that Class II, division 1 males are not significantly more long-headed than are Class I males, but instead Class I males are significantly greater in head breadth.

A clearer understanding of this difference may come out of a study of a variety of width measurements taken from the posteroanterior film, presently under way in this laboratory.

A discussion of clinical implications of these findings is beyond the scope of the paper, but this aspect is being explored and involves the formulation of indices based on measurements described here, in the hope of deriving a quantitative measure which may help to determine prognosis and treatment. In this connection, a reclassification of individual subjects in the study on the basis of skeletal characteristics most likely to be responsible for the anomaly emphasizes the need for films of this sort, supplementing the plaster models and photographs which have been considered adequate in the past.

SUMMARY

Lateral cephalometric films were taken on 48 girls and 45 boys having Class II, division 1 malocclusion (posterior occlusion of mandibular molars and premolars with those of the maxillary arch, and protruding maxillary incisors). For each of these individuals there was selected a person of the same sex and age with Class I malocclusion (irregularity of teeth, but with normal anteroposterior dental arch relationships), and films from these children with essentially normal facial proportions were used as controls. The mean age of each of the 4 samples was 11½ years. Twenty-one measurements were taken on these films to show significant differences in craniofacial anatomy.

Males were found to be significantly larger than females in the following dimensions in both classes: total cranial base length, length of cranial base from glenoid fossa to nasion, head breadth, head length; in Class II, division 1 only, overall length of mandible and overall length of maxilla.

Class II, division I males are larger than Class I males in overall maxillary length, but not in overall mandibular length; the maxillary first permanent molar is farther forward on the body of the maxilla, and the maxillary central and the anterior nasal spine are farther forward in relation to sella in Class II, division 1 males. Class I males have wider heads, with consequently larger cephalic index.

Class II, division 1 females are smaller than Class I females in overall mandibular length, and the maxillary central incisor is slightly farther forward with relation to sella.

Statistically speaking, the anomaly seems to be maxillary overdevelopment in males and mandibular underdevelopment in females, but individual cases demand specific analysis and frequently involve dimensions which cannot be made to show statistically significant differences in the mass.

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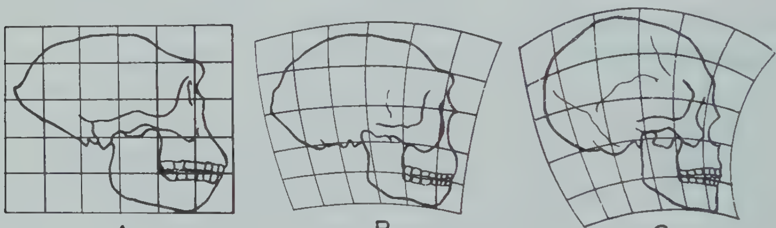
COMPARISONS BY COORDINATE TRANSFORMATIONS.— The development of the third theme in the last chapter of Thompson's *On Growth and*

Form] consists of his demonstration that related organic forms can often be compared by means of coordinate transformations. One of the most beautiful cases is provided by the deep sea fishes *Argyropelagus* and *Sternophyx.* If a drawing of *Argyropelagus olfersi* be made on graph paper and then for every point (x,y) a new point (ξ,η) be plotted such that

$$\xi = x + \eta \cot 70^\circ$$
$$\eta = y \sin 70^\circ$$

a very fair representation of *Sternophyx diaphanus* is obtained. One species has thus apparently been transformed into another by shearing. Few cases admit a precise mathematical description of this kind, but it is often possible to transform one species into another by imposing quite systematic, if empirical, distortions on the grid. An interesting example not known to Thompson is given in figure 1, where the main



outline of the skull (fig. 1A) of *Pithecanthropus robustus* in *norma lateralis* is converted into a representation (fig. 1B) of *P. pekinensis* by imposing almost uniform curvatures on each element of the rectangular grid, and into *Homo sapiens* (fig. 1C) by increasing the systematic variation in the curvature towards the vertex and towards the face. These transformations are of peculiar interest, because Thompson tells us that "Mr. Heilmann . . . has tried but without success to obtain a transitional series between the human skull and some pre-human, anthropoid type." This remark was written before either of the fossil forms of figure 1 were known; the considerable success of these transformations shows how justified Thompson was in his subsequent remark: "The failure is not the fault of our method." It is worth noting that if curvatures of sign opposite to those of figure 1B be imposed on the *P. robustus* diagram, a form with an enormous mandible will result, reminiscent of *Meganthropus* and *Gigantopithecus.* In every case of this sort a structure has been harmoniously changed as a whole, but no dynamic explanation of the process can yet be given.— G. Evelyn Hutchinson. In memoriam: D'Arcy Wentworth Thompson (1860–1948). Am. Sci., vol. 36, no. 4, October, 1948, pp. 577–581, 600, 602, 604, 606.

THE MEASUREMENT OF OBESITY IN CHILDHOOD

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The literature on human obesity is large, a situation appropriate, perhaps, to the nature of the subject. There are, however, curiously few studies of obesity in children which attempt to describe this condition precisely, both in terms of body bulk and of the amount of adipose tissue present as compared to other tissue components.

Where studies do indicate the criteria by which obese children were selected — and many studies do not — excess absolute body weight is often used, or excess weight as related to height. Other studies define obesity as excessive accumulation of fat in the body, and select cases by inspection or by direct caliper measurement of fat pads. Such procedures are correct in that classically obese individuals are absolutely overweight, overweight for their height, and have an excess amount of subcutaneous fat. These procedures are perhaps insufficiently selective, in that a group so chosen may still contain individuals who on further analysis cannot reasonably be considered as obese. In addition, such procedures may miss children who perhaps deserve to be classed as obese.

A recent textbook of pedriatrics (Nelson, '45) gives a good clinical definition of obesity, and at the same time points out some of the factors which may be responsible for conflicting results in various studies.

"There is no exact line of demarcation between normal nutrition and overnutrition and, practically, the diagnosis is made from the appearance of the child rather than from an arbi-

trary excess in weight. Children of the stocky type may have relatively large skeletal frames and more than the average amount of muscular tissue so that both their weight and appearance exceed that of the average child of their age, but they are not to be considered obese. Obesity or overnutrition is simply a generalized excess accumulation of fatty subcutaneous tissue." (p. 274.)

Although it is true that the borderline between a normal and an obese individual is purely arbitrary (Lauter and Terhedebrügge, '39), this is a situation found in many aspects of human development where a biologic continuum obtains. It should prove no obstacle to classifications based on direct measurements, if they prove of use both in research and as a supplement to clinical judgement.

Many studies, in addition to the above, have indicated that weight is no sure guide to a diagnosis of obesity, and doubt has been expressed by Bransby ('44) and others as to the value of indices derived from weight and height. Nor is fat loss always reflected by weight loss, since in certain cases individuals may compensate for loss of fat by increased muscular density (Kereilis and Cureton, '47).

In the present paper, 5 different "categories of obesity" are examined. Subjects of the Fels Research Institute, at two age-levels, are studied in terms of these categories, and those classed as "obese" by each method are further examined. Since these categories do not always pick out the same children, an opportunity is here provided to test the relative efficiency of each method as a selector of obese children. This is done by examining each individual child, and relating body mass to the distribution of tissue components within the body. From such examination, several different types of obesity seem to emerge, and these newly derived types are compared to the 5 original categories.

MATERIALS AND METHODS

The children in this study include 45 boys and 44 girls at 7.5 years of age, and 35 boys and 43 girls at 11.5 years of

age, all regular participants in the longitudinal growth program of the Fels Research Institute (Sontag, '46). Five boys and 6 girls appear in both age groups. The 5 obesity categories used are:

1. Excessive weight.
2. Excessive weight for height.
3. Excessive amount of subcutaneous tissue. This is called "total fat," and is the combined breadths of fat pads in 6 areas of the body: calf, hips, waist, chest, upper and lower arm (Reynolds, '45).
4. Excessive total fat for weight.
5. Excessive total fat for height.

For each category, the children within each age-sex group were ranked, from largest to smallest, and the 7 highest-ranking children designated as "obese." Mean rankings were calculated for these 7 children, by age-sex group, for the 5 criteria mentioned above, as well as for body height, and for breadths of fat, muscle and bone as seen in x-rays of the leg area (Reynolds, '44, '46). Means were also obtained for those children representing different types of obesity, as determined from an analysis of individual body structure. These two groups of data, together with the individual values, form the materials for discussion.

RESULTS

To give some idea of the associations shown between certain variables, coefficients of correlation (ρ) were calculated on the ranked children for a number of items. The results are shown in table 1.

It will be noted that weight shows higher associations with total fat, and with the three tissue breadths, than does height. The association of weight with height is fairly high, ranging between 0.72 and 0.82. It is particularly interesting to note that the breadth of fat in the calf is reasonably representative of the total breadth of fat, the values for ρ lying between 0.83 and 0.88. The inter-associations of the calf breadths are low.

Although age changes and sex differences are not the primary concern of this study, it may be mentioned that there is a tendency for the coefficient of correlation to increase with age, particularly in the girls, and that the girls in general tend to show higher values than do the boys.

Mean rankings, by age-sex group, for the 7 "obese" children as picked out by each obesity category, together with the means for the 4 groups combined, are shown in table 2.

TABLE 1

Positive coefficients of correlation (ρ) for selected variables

ITEMS COMPARED	BOYS		GIRLS	
	7.5 years (N = 45)	11.5 years (N = 35)	7.5 years (N = 44)	11.5 years (N = 43)
Wt. — ht.	.82	.80	.72	.77
Wt. — total fat	.55	.64	.68	.82
Wt. — calf fat	.57	.70	.51	.68
Wt. — calf muscle	.42	.55	.41	.68
Wt. — calf bone	.53	.63	.69	.71
Ht. — total fat	.40	.22	.19	.32
Ht. — calf fat	.36	.44	.11	.26
Ht. — calf muscle	.20	.34	.22	.50
Ht. — calf bone	.48	.36	.65	.67
Total fat — calf fat	.83	.84	.83	.88
Calf fat — calf muscle	.00	.20	.05	.32
Calf fat — calf bone	.23	.23	.30	.43
Calf muscle — calf bone	.00	.32	.02	.22

For example, in the first line of this table, the 7 boys of 7.5 years ranking highest in weight (i.e., 1, 2, 3, 4, 5, 6, 7; mean = 4), are compared relative to their mean rankings in 8 other variables.

Mean rankings in the 4 age-sex groups tend to show the same patterns, although there are certain differences which may be mentioned. Considering only weight and height rankings, boys tend to show higher values at 7.5 years, while the girls show higher values at 11.5 years. Boys tend to have

TABLE 2

Mean rankings[1] in 9 variables for the 7 children having highest values in each of 5 obesity categories

	WT.	WT./HT.	FAT	FAT/WT.	FAT/HT.	HT.	CALF FAT	CALF MM.	CALF BONE
I. Weight									
Boys, 7.5 yrs.	4	4	6	10	7	9	6	14	10
11.5 yrs.	4	5	8	10	9	11	8	11	10
Girls, 7.5 yrs.	4	4	8	18	11	13	10	5	11
11.5 yrs.	4	5	12	22	14	8	15	7	9
II. Weight/height									
Boys, 7.5 yrs.	4	4	6	10	7	9	6	14	10
11.5 yrs.	5	4	6	8	7	14	8	10	9
Girls, 7.5 yrs.	4	4	8	18	11	13	10	5	11
11.5 yrs.	5	4	6	13	8	13	7	7	9
III. Total fat									
Boys, 7.5 yrs.	4	4	4	7	4	10	5	15	14
11.5 yrs.	9	8	4	5	4	16	6	15	17
Girls, 7.5 yrs.	10	7	4	9	5	20	6	11	17
11.5 yrs.	9	7	4	6	4	19	5	11	13
IV. Total fat/weight									
Boys, 7.5 yrs.	16	15	7	4	6	20	8	20	21
11.5 yrs.	15	13	6	4	5	22	9	15	20
Girls, 7.5 yrs.	20	14	7	4	6	32	10	23	23
11.5 yrs.	16	12	5	4	4	29	6	19	19
V. Total fat/height									
Boys, 7.5 yrs.	4	4	4	7	4	10	5	15	14
11.5 yrs.	10	9	5	5	4	18	6	14	16
Girls, 7.5 yrs.	16	11	5	5	4	28	9	19	20
11.5 yrs.	9	7	4	6	4	19	5	11	13
Age and sex groups combined									
Weight	4	4	8	15	10	10	10	9	10
Weight/height	4	4	6	12	8	12	8	9	10
Total fat	8	6	4	7	4	16	6	13	15
Total fat/weight	17	14	6	4	5	26	8	19	21
Total fat/height	10	8	4	6	4	19	6	15	16

[1] In all tables, rankings are given to nearest whole number.

higher mean rankings at 7.5 years than girls, while at 11.5 years there is little difference. Attention may most profitably be turned to the last grouping in table 2, where the 4 age-sex groups are combined.

It will be seen that, in the present series, when "obese" children are selected by weight and by weight/height, the 9 variables show similar mean values. The same is true for total fat and for total fat/height. Children selected by the total fat/weight index show mean values quite different from the other categories. This can be shown most conveniently by translating into general descriptive terms the mean ratings in table 2:

VARIABLE	OBESITY CATEGORY: Weight and weight/height	Total fat and total fat/height	Total fat/weight
Weight	Heavy	Moderately heavy	Average
$\frac{\text{Weight}}{\text{Height}}$	Very stocky	Stocky	Slightly stocky
Total fat	Thick	Very thick	Thick
$\frac{\text{Total fat}}{\text{Weight}}$	Above average	Thick	Very thick
$\frac{\text{Total fat}}{\text{Height}}$	Thick	Very thick	Very thick
Height	Tall	Taller than average	Short
Calf fat	Rather thick	Thick	Rather thick
Calf muscle	Rather thick	Thicker than average	Average
Calf bone	Rather thick	Thicker than average	Average

Weight and the weight/height index, therefore, when used as criteria of obesity, pick out children who are tall and heavy, but whose tissue distribution, as seen in the calf, is not selective of any particular tissue. Total fat and total fat/height, when used as obesity criteria, tend to pick out children who are moderately heavy and taller than average, and who show a certain amount of selectivity in tissue distribution, in that calf fat is disproportionately thick. The

total fat/weight index tends to pick out children who are average in weight and short in stature, and whose tissue distribution is markedly skewed in the direction of excessive breadth of fat in the calf.

In table 3, the individual rankings are given for the 50 children who were selected as "obese" by one or more of the obesity categories discussed above. Since there are 7 children selected by each of 5 obesity categories, there are 35 cases within each age-sex group. Some children, however, are selected as "obese" by more than one category; e.g., case no. 81 at 7.5 years, is included in all 5 categories. This one individual, therefore, accounts for 5 of the 35 cases within this age-sex group. On the other hand, case no. 160 was selected by only one obesity category. The 50 children shown in table 3 thus represent 140 cases (7 top-ranking cases $\times$ 5 obesity categories $\times$ 4 age-sex groups).

In the final column of this table, under "obesity classification," is shown the type of obesity to which the child was assigned, based on an analysis of individual body structure, as described below.

It appears to the authors of this paper that a classification of obesity should include at least three factors: body weight, some measure of the amount of fat present, and some measures of the amounts of other tissues present. To be classed as truly *obese,* an individual should be excessively heavy in weight, and it should be established that his overweight is derived principally from an excess accumulation of body fat. In table 3, those children who appeared to satisfy these conditions were classed as obese.

Obesity which includes excess accumulations of other tissues, such as muscle and bone, as well as adipose tissue, is a different kind of obesity from the above. An individual in this category is perhaps more properly classified as generally massive, or *mixed obese.* In any event, he should in some way be distinguished from the unmixed type.

It also seems there should be some category or categories of obesity which include individuals who have a dispropor-

TABLE 3

Individual rankings for children selected as "obese" by indicated categories, and obesity classification shown by analysis of individual cases

CASE NO.	OBESITY CATEGOREIS	WT.	WT./HT.	FAT	FAT/WT.	FAT/HT.	HT.	CALF FAT	CALF MM.	CALF BONE	OBESITY CLASSIFICATION
					7.5 year boys (No. of cases: 35; no. of children: 11)						
81	All five	2	2	3	3	3	4	4	14	10	Obese
190	All but IV	2	2	4	8	5	4	3	9	7	Obese
71	All but IV	2	3	6	10	6	4	5	26	4	Mixed obese
78	All five	4	4	1	2	2	10	1	3	24	Mixed obese
135	All five	5	5	5	4	4	10	2	23	16	Obese
153	All but IV	6	6	7	18	7	16	10	20	2	Not obese
215	I, II	7	7	16	26	20	16	19	2	7	Not obese
208	III, IV, V	10	9	2	1	1	21	10	11	38	Mixed obese
102	IV	43	42	19	4	15	44	19	39	42	Rel. obese
186	IV	18	14	8	6	8	24	6	45	4	R. mixed obese
160	IV	31	30	10	6	10	26	15	6	10	R. mixed obese
					11.5 year boys (No. of cases: 35; no. of children: 12)						
20	All five	1	1	2	3	2	13	2	4	10	Mixed obese
135	All five	2	2	1	1	1	10	1	3	22	Mixed obese
81	I, II, III	4	5	6	11	8	8	6	19	16	Obese
78	All but IV	4	6	4	10	5	7	4	12	4	Mixed obese
45	All five	6	3	3	2	3	20	9	6	8	Mixed obese
92	I	6	12	31	34	33	1	21	8	8	Not obese
153	I, II	6	4	9	12	10	16	16	24	1	Not obese
26	II	12	7	18	22	18	20	23	2	2	Not obese
77	III, IV, V	20	10	5	6	4	29	9	22	28	Rel. obese
23	III, IV, V	24	25	7	6	6	23	5	35	30	Rel. obese
102	IV	33	33	14	4	11	33	18	22	32	Rel. obese
47	IV, V	16	16	10	7	7	26	16	15	13	Rel. mixed obes
					7.5 year girls (No. of cases: 35; no. of children: 14)						
205	I, II, III	1	1	4	20	8	2	12	9	3	Mixed obese
140	I, II	2	7	18	32	26	1	16	8	3	Not obese
105	I, II	3	6	14	28	18	3	18	1	23	Not obese
72	I, II	4	3	12	24	12	19	12	8	12	Not obese
91	All five	5	4	2	3	3	14	4	5	3	Mixed obese
191	I, II, III	6	4	7	17	10	19	9	3	12	Not obese
86	All five	6	2	1	2	2	36	1	2	23	Mixed obese
214	III, IV, V	37	22	3	1	1	44	6	20	44	Rel. obese
171	III, V	10	9	6	8	6	14	9	18	8	R. mixed obese
76	III, V	8	8	6	10	4	10	4	22	23	Obese
185	IV, V	24	18	9	4	6	39	22	32	32	Rel. obese
66	IV, V	19	14	9	6	6	39	18	32	8	R. mixed obese
148	IV	19	16	9	6	10	22	2	42	16	Rel. obese
151	IV	28	24	16	7	13	32	16	25	37	Rel. obese
					11.5 year girls (No. of cases: 35; no. of children: 13)						
5	All but IV	1	1	2	12	2	10	4	1	1	Mixed obese
105	All but IV	2	3	5	10	7	1	6	2	8	Not obese
72	All five	3	2	4	7	4	16	4	4	13	Mixed obese
3	I, II	4	5	20	39	28	2	20	10	4	Not obese
121	I	5	8	32	43	36	4	40	6	2	Not obese
37	I, II	6	4	10	17	10	13	11	18	13	Mixed obese
27	I	7	10	14	24	14	10	20	8	25	Not obese
86	All but I	10	6	4	4	3	28	2	2	20	Mixed obese
91	All but I	10	7	1	2	1	20	1	7	8	Obese
148	III, IV, V	20	18	6	2	5	28	2	42	24	Rel. obese
94	III, IV, V	15	11	7	5	6	28	11	18	20	Rel. obese
66	IV	28	22	10	4	8	40	14	36	20	Rel. obese
75	IV	26	20	12	6	10	38	8	24	27	Rel. obese

(Total no. of cases: 140; total no. of children: 50)

tionate amount of body fat, in constrast to muscle and bone, but who are not excessively overweight for their age and sex. Such children are classified in table 3 as *relatively obese.* An additional group, *relatively mixed obese,* includes those children in whom one of the other tissues is also disproportionately prominent.

There seems to be no justification for classifying individuals as obese, when it can be shown that their excess weight is derived from tissues other than fat. In table 3, such children are called *not obese.*

TABLE 4

Mean rankings in 9 variables for the 50 children selected by the 5 obesity categories, by actual type of obesity shown

TYPE OF OBESITY	NO.	WT.	WT./HT.	FAT	FAT/WT.	FAT/HT.	HT.	CALF FAT	CALF MM.	CALF BONE
Obese	6	5	5	4	5	4	9	3	16	13
Mixed obese	14	4	4	3	7	4	15	5	8	13
Relative obese	12	27	22	10	4	8	33	11	30	29
Relative mixed obese	5	19	17	9	7	7	26	13	23	9
Not obese	13	5	6	16	25	18	10	18	8	8
Total	50									

The mean rankings in the 9 variables, for the 4 newly derived types of obesity and for the group classed as not obese, are shown in table 4.

As seen in table 4, children classed as obese are heavy in weight, and seem to derive their overweight primarily from fat. Mixed obese children are also heavy in weight, but their tissue distribution shows a lower mean ranking for fat and a higher mean ranking for muscle. Relatively obese children are actually below average in body weight, but show a disproportionate amount of fat in the calf. Relatively mixed obese children are average in weight, show relatively high rankings in fat, but even higher rankings in bone. Chil-

dren classified as not obese are heavy in weight, but seem to derive their bulk primarily from muscle and bone, rather than from excessive fat.

In table 5, the 50 children listed in table 3 are distributed, both by the 5 original obesity categories used, and by the 5 types of obesity (including the not obese group) derived from individual inspection.

The obesity categories of weight and weight/height index pick up most of the children classed as obese, as well as most of the children classed as mixed obese. These two categories do not, of course, select children of the relatively obese type or of the relatively mixed obese type. Also, these two categories pick out most of the children classed on individual inspection as not obese.

TABLE 5

Distribution of obesity categories by type of obesity shown by individual children

TYPE OF OBESITY	OBESITY CATEGORY				
	Weight	Weight/Height	Total fat	Total fat/Weight	Total fat/Height
Obese (6)	4	5	6	3	5
Mixed obese (14)	12	13	13	9	12
Relative obese (12)	0	0	5	12	6
Relative mixed obese (5)	0	0	1	4	3
Not obese (13)	12	10	3	0	2
	28	28	28	28	28

The total fat and the total fat/height categories pick out most or all of the obese children, and most of the mixed obese children. These categories also catch almost half of the relatively obese group and the relatively mixed group. In addition, they include a small number of children classed as not obese.

The total fat/weight category selects half of the obese group, most of the mixed obese and the relatively mixed obese groups, all of the relatively obese children, and no children considered as not obese.

In plate 1, photographs and individual values are shown for children of 11.5 years representing each of the 5 types of obesity described in this paper.

DISCUSSION

It is evident that none of the 5 categories of obesity herein examined are completely effective in selecting children from all 4 types of obesity, as we have described them, while at the same time rejecting children who are not obese. Weight and weight/height pick out most of the obese and mixed obese children, but unfortunately also pick out children who are not obese. Nor do these two categories select any children from the relatively obese groups. Total fat is perhaps the most efficient single category; however, three children who are not obese are also included. Total fat/height shows about the same pattern as total fat. Total fat/weight is less effective in selecting obese and mixed obese children, but picks out almost all of the relatively obese children, and does not include any children who are not obese.

It seems likely that some of the conflicting results found in various studies of human obesity may stem from the fact that these studies failed to discriminate between various kinds of obesity, and at times actually included individuals who cannot reasonably be considered as obese.

Whether classifications of obesity follow the lines set down in this paper, or whether some other system of classification is used, does not appear to the writers of this paper to be particularly important. It does seem important to point out that the selection of obese subjects on the basis of weight, height, breadth of fat, or indices derived from these variables, without a more critical consideration of the differential tissue structure of the body, may result in an unrepresentative group.

SUMMARY

A series of 167 children from the Fels Research Institute were ranked with reference to the degree of obesity shown,

as measured by 5 different categories: weight, weight/height, total fat, total fat/weight and total fat/height. The 50 children who, by one or more of these methods, were selected as "obese," were further studied in terms of body bulk and of the distribution of fat, muscle and bone in the calf. From this analysis 5 types emerged: obese, mixed obese, relatively obese, relatively mixed obese and not obese. The relative efficiency of each of the original categories of obesity is examined in terms of the type of obesity assigned to each individual child. It is suggested that conflicting results in the study of human obesity may have arisen from failure to differentiate types of obesity.

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PLATE 1

EXPLANATION OF FIGURES

Individual values at 11.5 years.

Selected as "obese" by following obesity categories:	W/H, F, F/W, F/H	W, W/H, F, F/H	F, F/W, F/H	F/W, F/H	W, W/H
Classification made after study of individual tissue distribution:	Obese	Mixed obese	Relative obese	Rel. mixed obese	Not obese
Ranking (even units):					
Weight	10	1	20	16	6
Weight/height	7	1	18	16	4
Total fat	1	2	6	10	9
Fat/weight	2	12	2	7	12
Fat/height	1	2	5	7	10
Height	20	10	28	26	16
Fat in calf	1	4	2	16	16
Muscle in calf	7	1	42	15	24
Bone in calf	8	1	24	13	1

Loss of Předmost Originals.— In the Annual Report of the Faculty Board of Archaeology and Anthropology on the Museum of Archaeology and of Ethnology [Cambridge], 1946–1947, there is a parenthetical statement attributed to J. C. Trevor to the effect that the originals of Předmost III and IV were destroyed during the war.

Classifications of Dental Mutilations.— Because of the complete isolation thought to exist between the Old and New World which prevented contact with the Phoenicians and their Mediterranean neighbors, one wonders then how these same Indians practiced the simple restorative prosthesis of the former, yet in archaeological literature such type of dental prosthesis has been reported in Ecuador . . .

In the Southern hemisphere we find these mutilations, and with greater variety, in almost every country from Argentina to Venezuela but [as van Rippen says:] "not with all the tribes or peoples of one particular country. This is not strange when one considers other customs which have been in practice by one tribe since remote times, but never acquired by the neighboring peoples."

From Costa Rica the custom spread north through Central America into Mexico to the region occupied by the Zapotecs, Mayas, Huaxtecs, Totonacs, Cholutecs and Mexicans. It is here that the latest study of the subject has been made by Daniel F. Rubín de la Borbolla and Luciano Alexanderson. The former has arranged a classification made up of 24 types of tooth mutilations found in Mexico and known up to the present time. To his alphabetical group we have (in numbers) added some variations in form and types as found elsewhere (fig. 68 and fig. 70).— Bernhard Wolf Weinberger. An Introduction to the History of Dentistry, with medical and dental chronology and bibliographic data. 2 vols. (title of second volume somewhat different). The C. V. Mosby Co., St. Louis, 1948, volumes separately paged and indexed: 514 and 408 pp., respectively, extensively illustrated.

(In this connection see also the following article by Ambrosio Delfino: Alteraciones dento-maxilares intencionales de carácter étnico; nueva clasificación. Rev. Mus. La Plata, n.s., vol. 4, sec. Antropología, 1948, pp. 93–116.— Ed.)

AGE CHANGES IN HEAD HAIR FROM BIRTH TO MATURITY[1]

I. INDEX AND SIZE OF HAIR OF CHILDREN

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SIX FIGURES

The index and size of hairs from the same region of the same scalp have been shown to vary widely. Likewise, a single hair may vary to a lesser degree along its shaft (Kneberg, '35; Seibert and Steggerda, '42). It has also been suggested that a sex difference in index occurs during the first decade of life and that within this period the size of hairs gradually increases (Trotter, '30).

Studies on age changes of head hair have been made on samples taken from different individuals of various ages (Leonard, 1879; Wynkoop, '29; Trotter, '30, Trotter and Dawson, '34). It is believed that an examination of hair from the same individual taken at regular intervals over a long period of time may be of interest. The plan is to study the structural characteristics of hair from a few individuals throughout the period from birth to maturity. This paper is concerned only with the index and size or cross-sectional area of hair from birth to 17 years of age.

MATERIAL AND METHOD

Sixteen White children of American parentage are providing the hair samples for this study. The vertex of the

[1] This investigation was supported (in part) by a research grant from the Viking Fund, Inc. and (in part) by a research grant from the Division of Research Grants and Fellowships of the National Institute of Health, U. S. Public Health Service.

head is the region chosen because it is well-defined and, thus, directions for those taking samples are simplified. In addition, the hair of the vertex appears to be more uniform than that nearer the periphery (Pinkus, '27). The mother of each child agreed to cut a lock of hair from the vertex on each monthly birthday and mail it to our laboratory.[2] There have been occasional lapses but, on the whole, the record is good. Collection has been in progress since June, 1930. The plan is to continue it until each individual is 25 years of age.

The designation of each individual, the sex, and the date of birth are as follows:

A	boy	6-10-30	I	girl	4-28-36
B	girl	10- 1-32	J	girl	5-17-36 [2]
C	boy	10-23-32	K	boy	8- 6-36
D	girl	4-11-33	L	girl	3-24-38 [3]
E	girl	1- 3-34	M	girl	3-24-38 [3]
F	boy	3- 1-34	N	girl	4-18-38
G	boy	6-24-35 [1]	O	boy	4-28-38
H	girl	6-27-35	P	boy	4-29-42

[1] No samples after 1946.
[2] No samples during 1st year.
[3] No sample until 3rd month.

There are 5 pairs of siblings in the group: B and F, C and K, E and N, L and M (identical twins), and O and P. Subjects C and K are cousins of O and P (the father of the former pair and the mother of the latter pair are brother and sister).

The index and size of the hairs have been determined from measurements taken as close to the proximal end of the hair shaft as was feasible. These measurements consist of the greatest and least diameters and were determined at a magnification of 120 with the aid of an ocular micrometer on which one space or .05 mm represented .00833 mm on the hair. Two methods were employed in measuring a hair: the hair rotation method and the cross-section method. The hair rotator does not differ essentially from that described

[2] We acknowledge with thanks the cooperation of both the mothers and the children.

by Danforth ('26), however, the frame is attached to the rim of the stage of the microscope by screws rather than resting on its surface. The cross sections were made by utilizing the Hardy microtome; strands of cotton thread as a filler were placed in the groove along with the hairs.

Fifty hairs taken at random from each sample at 6 month intervals were measured to determine the greatest and least diameters. Thus, for each year, 100 hairs were measured: for the 1st year, 50 from the one-month sample and 50 from the 7-month sample; for the second year, 50 from the one-year-one-month sample and 50 from the one-year-7-month sample, and so on. The index was determined by the formula:

$$\frac{\text{least diameter} \times 100}{\text{greatest diameter}}$$

and the size or area of a cross section of the hair at the level at which the index was found, by the formula:

$$\tfrac{1}{2} \text{ greatest diameter} \times \tfrac{1}{2} \text{ least diameter} \times 3.1416$$

In application to hair both formulae are based on the assumption that the outline of the cross section of the shaft is regular and symmetrical.

For one subject both methods were applied throughout the series of samples and the results of both are presented for comparison. Although the hairs which were sectioned were not necessarily the same as those measured by the rotation procedure they were taken from the same samples. Since the differences in results between the two methods are small and since the cross-section method has the advantage of providing a permanent record, a change in the method was instituted from rotation to sectioning after samples of the earlier years had been measured.

COMPARISON OF METHODS

The hair samples of subject A were utilized for the comparison of the rotation and the cross-section methods.

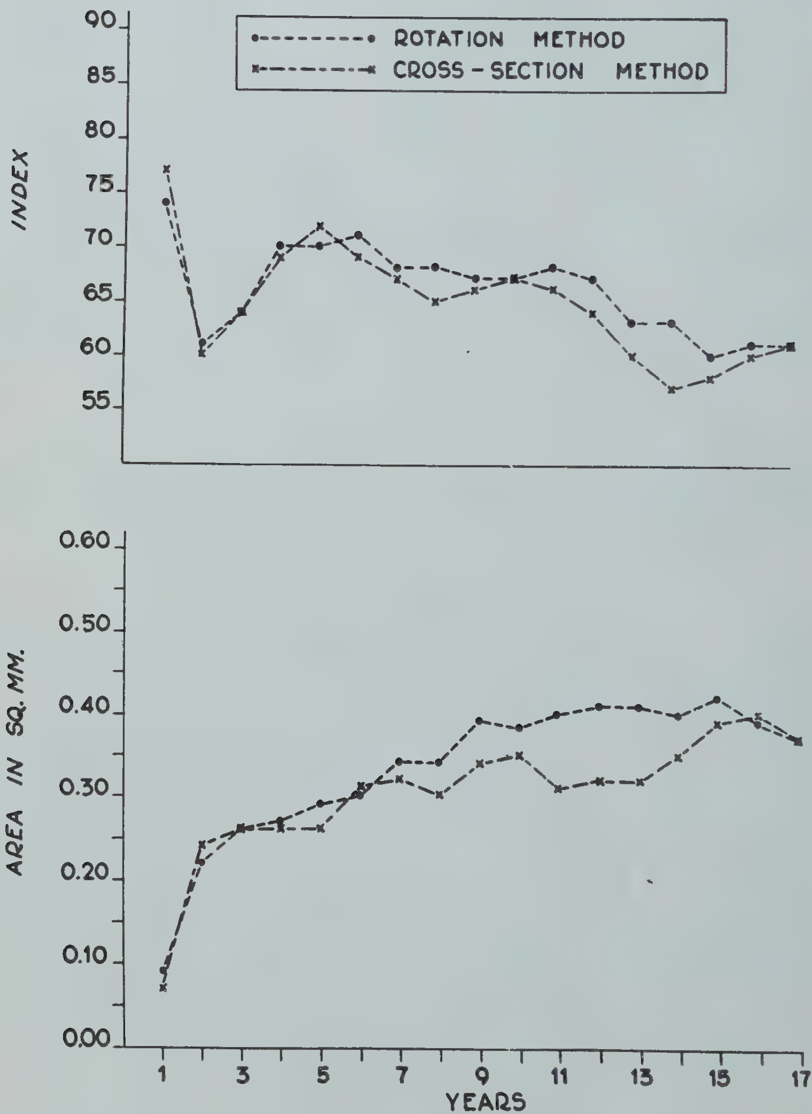

Fig. 1 Comparison of rotation and cross-section methods based on hairs of Subject A. For each year (in this and in succeeding figures) the average measurement of 100 hairs is recorded. Upper, index curves; lower, area curves.

The average indices determined from measurements made by the 2 methods are recorded graphically on a yearly basis in figure 1 (upper). The average index for the entire group of 1700 hairs measured by the rotation method is 65.82 and by the cross-section method is 64.89. The difference between them is only one unit; likewise, differences within any given year are slight. There is a tendency for the cross-section method to present the lower index. The range present in all samples (from 30 to 46 units for each sample by the rotation method and from 32 to 55 units for each sample by the cross-section method) is also slightly greater when the hairs are measured by the cross-section method.

The sizes, or cross sectional areas, derived from the same diameters on which the indices are based are presented in figure 1 (lower). The range in size of hairs increases with age. Throughout the 17 years it extends from .000218 mm^2 (the smallest hair in the first year) to .0075 mm^2 (the largest hair in the 17th year). The difference in area between the smallest and the largest hair measured in the one-month sample is .0010 mm^2 and in the 16-year-7month sample is .0053 mm^2. The total areas of 100 hairs for each year by the two methods show a close correlation excepting in a few instances. The differences in results of the two methods are not always consistent. In a few instances, the area determined by the cross-section method is larger, but more often the area determined by the rotation method exceeds that determined by the cross-section method. This tendency for the cross-section method to give smaller areas is more evident when the total areas of the 1700 hairs determined by the two methods are compared. The total areas for the 1700 hairs are 5.68 mm^2 for the rotation method and 5.17 mm^2 for the cross-section method.

INDEX

The average index for each of the 16 individuals varies from year to year with only an occasional exception (table 1). There is a drop after birth which continues during the first

2 years. This drop is more marked between the one-month and the 7-month measurements than between any of the successive measurements thereafter. Following the second year there is irregularity in successive indices. The lack of a general trend may indicate a tendency on the part of the indices to

TABLE 1

Average indices of 100 hairs per year for each subject

YEAR	SUBJECT															
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1 mo.	75	67	81	78	87	81	93	79	81	..	83	71	73	87	76	76
7 mo.	74	66	73	71	80	69	78	81	73	..	72	69	67	81	76	70
1[1]	74	66	77	74	84	75	85	80	77		77	70	70	84	76	73
2	61	62	71	65	73	66	76	79	71	74	70	65	66	73	73	73
3	64	65	67	65	76	66	82	77	74	67	72	63	63	69	72	72
4	70	67	70	60	76	69	78	77	73	65	76	63	63	78	73	70
5	70	67	69	65	73	70	81	74	75	66	77	58	59	80	72	70
6	71	67	75	64	75	70	81	75	82	67	74	59	63	79	74	68
7	68	63	74	62	75	70	85	79	85	67	80	62	62	78	80	..
8	68	62	74	65	79	66	80	81	85	69	73	63	63	83	81	..
9	67	66	74	63	81	67	80	81	84	66	77	61	67	83	73	..
10	67	61	75	59	78	71	80	81	83	67	81	58	61	84	73	..
11	68	63	74	68	78	72	81	79	83	69	78	..	.	..	..	..
12	67	62	70	68	80	71	83	80	83	67	78	..	.	..	..	..
13	63	59	72	70	82	69	..	80	..	.	..	..	..	..	..	..
14	63	68	76	67	79	72	..	..	..	..	..	..	..	..	..	..
15	60	62	71	69	.	..	..	..	..	..	..	..	..	.	..	..
16	61	..	..	.	..	..	..	..	..	..	..	..	..	..	..	..
17	61	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Total	66	64	72	66	78	69	81	79	80	68	76	62	63	79	75	71

[1] Indices for the first year are given in detail, i.e., the average index of 50 hairs from the 1-month sample and the average index of 50 hairs from the 7-month sample. Together, they constitute the average index of 100 hairs for the first year of life. The exception is for subjects L and M, in which cases the first samples were taken at 3 months.

remain constant. No difference between the indices of hair of boys and girls is apparent until after the third year of life. Succeeding the third year 5 of the 9 girls maintain a lower index than the remaining 4 girls whose indices are similar to those of the boys. Curves for each child are shown in figure 2.

The indices of the hair of the siblings indicate a closer relationship than do those of most unrelated subjects (figure 3). This may be clearly seen in the curves of subjects B and F where the fluctuations follow the same direction yearly, excepting during the 10th year. The curves of N and

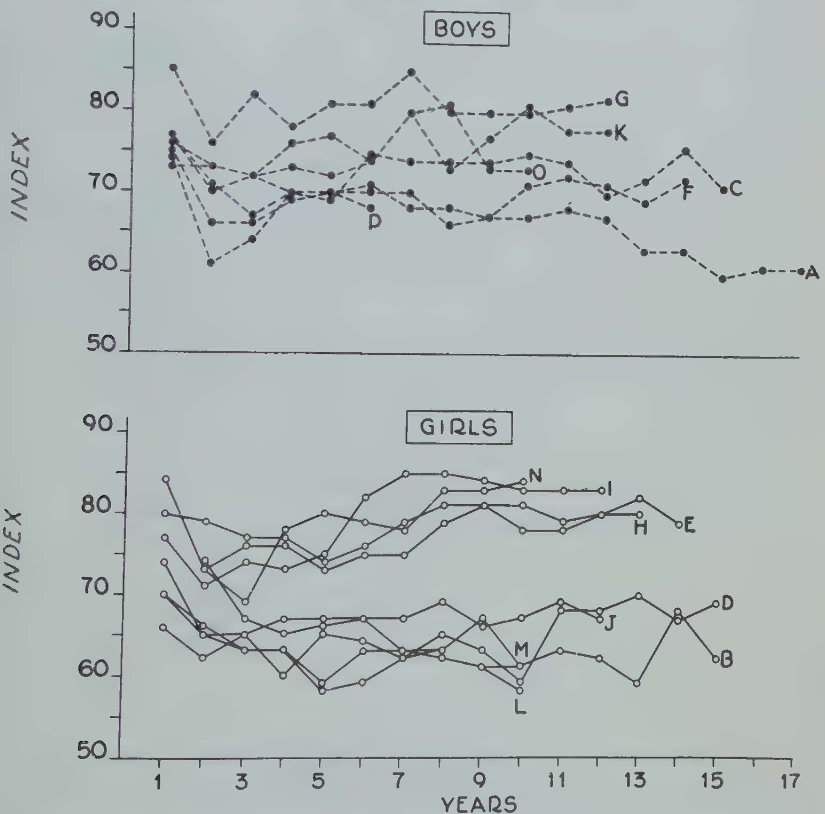

Fig. 2 Graphs showing average yearly index for each of the 16 children.

E parallel each other quite closely. In the comparison of indices of C and K there is present greater fluctuation in the curve of K than of C between the 6th and 9th years; otherwise there is close parallelism. Since subject P is only 6 years old, the comparison with his brother, subject O, cannot be carried far enough to be indicative. The curves of

subjects L and M, the identical twins, run together more closely than do those of any of the other siblings. The total average index for each child ranges from 62 to 81. If, arbitrarily, the indices, 62 through 69, are considered to be low, those from 70 through 79, medium, and an index of 80 and

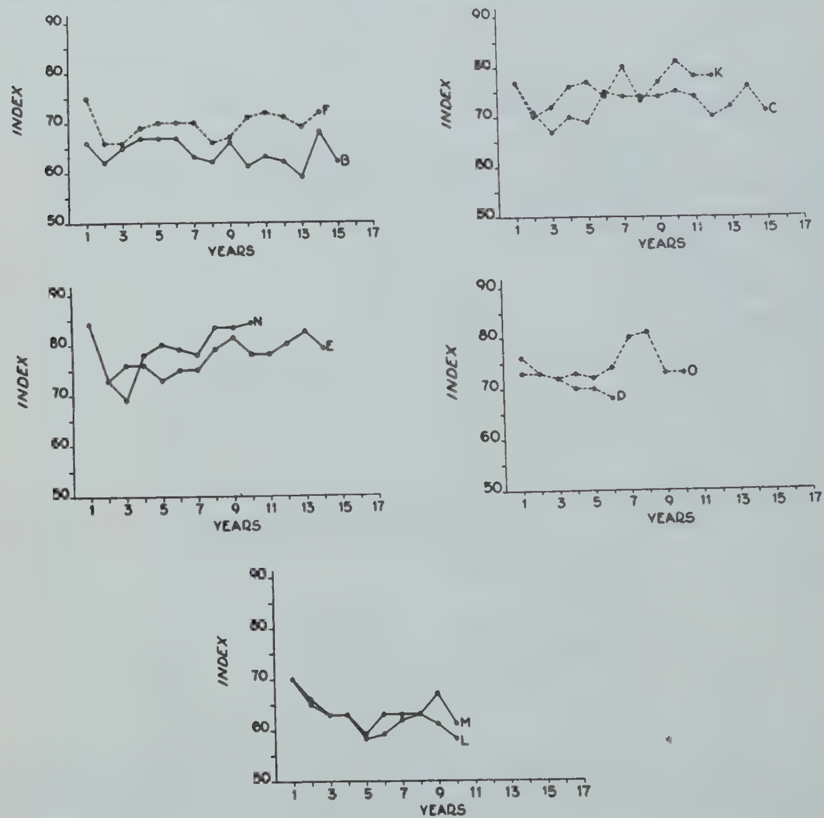

Fig. 3 Graphs showing average yearly index for each of the siblings. Broken line, boys; solid line, girls.

above, high, each pair of siblings has total average indices within the same division; siblings L and M, and E and N differ by only one unit.

It was pointed out above that the formula for determining the index of a hair implies a regular cross-sectional outline of the hair shaft. Whereas, the great majority of head hairs

of the white race are regularly oval in outline there are present occasionally hairs of unusual shape. In this series of individuals, the samples of subject B present a number of hairs of marked triangular outline in cross section; others, in which a few hairs of triangular contour are present, are

TABLE 2

Total size or cross-sectional area in mm² of 100 hairs per year for each subject

YEAR	SUBJECT															
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1 mo.	.03	.03	.02	.03	.02	.02	.01	.01	.02	..	.03	.06	.06	.02	.03	.03
7 mo.	.04	.07	.03	.04	.04	.07	.03	.04	.05	..	.06	.07	.07	.04	.02	.06
1 [1]	07	.10	.05	.07	.06	.09	.04	.05	.07	..	.09	.12	.13	.05	.05	.08
2	.24	.24	.20	.16	.17	.24	.18	.10	.18	.21	.22	.22	.19	.16	.20	.20
3	.26	.22	.28	.17	.23	.32	.27	.14	.21	.27	.28	.27	.25	.20	.20	.21
4	.26	.34	.35	.21	.24	.33	.28	.18	.24	.31	.29	.31	.30	.23	.25	.24
5	.26	.36	.40	.23	.24	.32	.29	.19	.25	.30	.32	.31	.33	.18	.22	.24
6	.31	.40	.39	.26	.26	.36	.30	.22	.24	.28	.37	.32	.33	.24	.29	.25
7	.32	.40	.41	.27	.25	.38	.32	.26	.24	.30	.31	.37	.35	.30	.29	..
8	.30	.44	.45	.28	.25	.40	.34	.24	.23	.31	.37	.36	.33	.28	.31	..
9	.34	.41	.46	.30	.23	.38	.37	.26	.24	.34	.40	.37	.38	.29	.34	..
10	.35	.46	.47	.27	.24	.30	.36	.27	.28	.32	.39	.40	.42	.27	.36	..
11	.31	.33	.48	.30	.24	.28	.37	.28	.28	.33	.38	..	..	..	..	..
12	.32	.42	.45	.34	.23	.32	.37	.29	.30	.34	.36	..	..	..	..	..
13	.32	.31	.51	.31	.23	.37	..	.28	..	..	..	..	..	..	..	..
14	.35	.30	.55	.31	.25	.30	..	..	..	..	..	..	..	..	..	..
15	.39	.36	.55	.32	..	..	..	..	..	..	..	..	..	..	..	..
16	.40	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
17	.37	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

[1] Total sizes or cross-sectional areas of 50 hairs are given for the 1-month and for the 7-month samples. Together they constitute the total size or area of 100 hairs for the first year. The exception is for subjects L and M, in which cases the first samples were taken at 3 months.

G, L and M. In the samples of subject F a few hairs are more flattened on one side than the other and, thus, approach a kidney-shaped outline. The samples of subject C include a few hairs of both kidney-shaped and triangular outlines. The remaining 10 subjects have a negligible number of hairs, if any, of irregular contour.

SIZE

The total size, or cross-sectional area, of 100 hairs of each individual for each successive year shows, in general, an increase (table 2). The increase during the 1st three years is more rapid and more uniform than for any period thereafter (fig. 4) and of these three years the greatest increase occurs during the 2nd year. When the areas for each 6 months' measurements are compared, the increase during the 2nd half of the 1st year (i. e., between the 7-month samples and the one-year-one-month sample) is greater than during the 1st half of the 1st year (i.e., between the one-month and 7-month samples) or any other 6 month period. When the curves for the boys and girls are superimposed the area of the hair between the 2nd and 8th years of more than half the girls is seen to be smaller than the area of the hair of the boys during the same period (fig. 5). However, only one of these girls, subject J, is among those who presented the low index curves.

The areas of the hair of siblings agree closely in most years and the fluctuations in the curves follow the same general pattern (fig. 6). Subjects B and F diverge during the 3rd and 10th years; subjects C and K during the 4th and 7th years; subjects O and P run together closely for the 1st 6 years or for the extent of P's age. The area curves for the identical twins, L and M, maintain a close correlation for their entire age span of 10 years.

For the entire group of children, the percentage of small hairs persisting throughout the age span was determined by arbitrarily limiting the hairs in this group to those with a cross-sectional area no larger than .0015 mm². In the one-month samples 99.7% of all the hairs measured are of this size or smaller; in the 7-month samples, 93.2%; in the one-year-1-month samples, 38.8%; in the 1-year-7-month samples, 24.6%. The decrease continues gradually to about 2 or 3% at 6 years of age when it becomes more or less stabilized. The large percentage of small hairs in the one-month and the 7-month samples is probably due to the persistence of lanugo

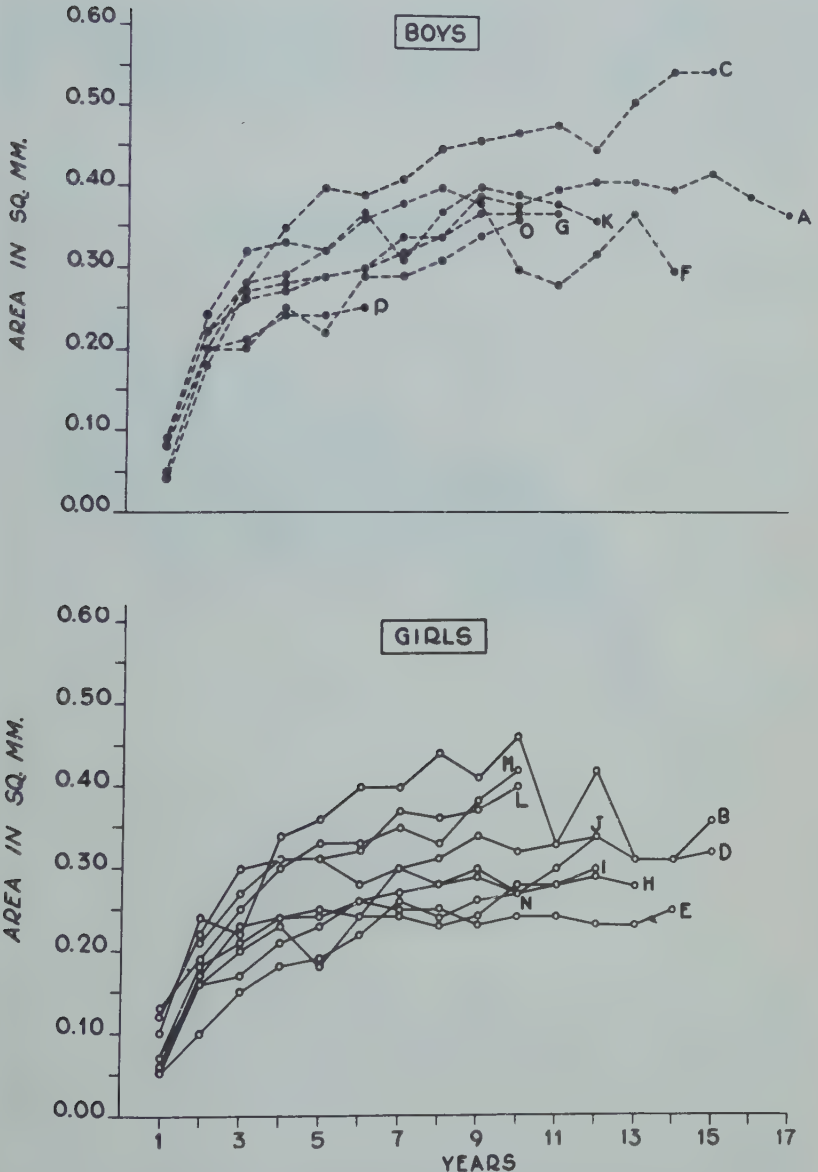

Fig. 4 Curves showing total yearly cross-sectional area of 100 hairs for each of the 16 children.

hairs during the first year of post-natal life and to very small vellus hairs. The reduction of the number of small hairs with increase in age indicates further transition from the lanugo to the vellus hairs and to the intermediate and terminal types.

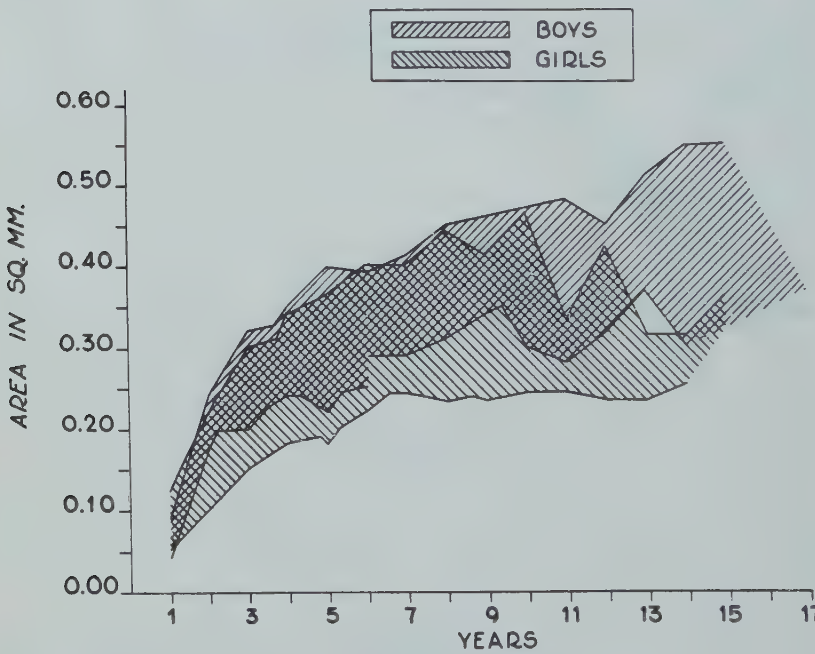

Fig. 5 Range of area curves of boys and girls.

DISCUSSION

The observations on this series of hair samples from children show that the shape of the cross-section of the hair shaft, as indicated by the index, changes from a more nearly round to a more oval form during the 1st two years of life and in the succeeding years presents fluctuations with no consistent trend; the increase in size, or cross-sectional area, occurs at a rapid and uniform rate during the 1st three years of life and less uniformly and somewhat less rapidly thereafter.

The significance of the shape or index of hair is not entirely understood. That it is a characteristic indicative of the behavior (straight, wavy, curly or frizzly) of the hair is true only in a very general way. The drop in index after

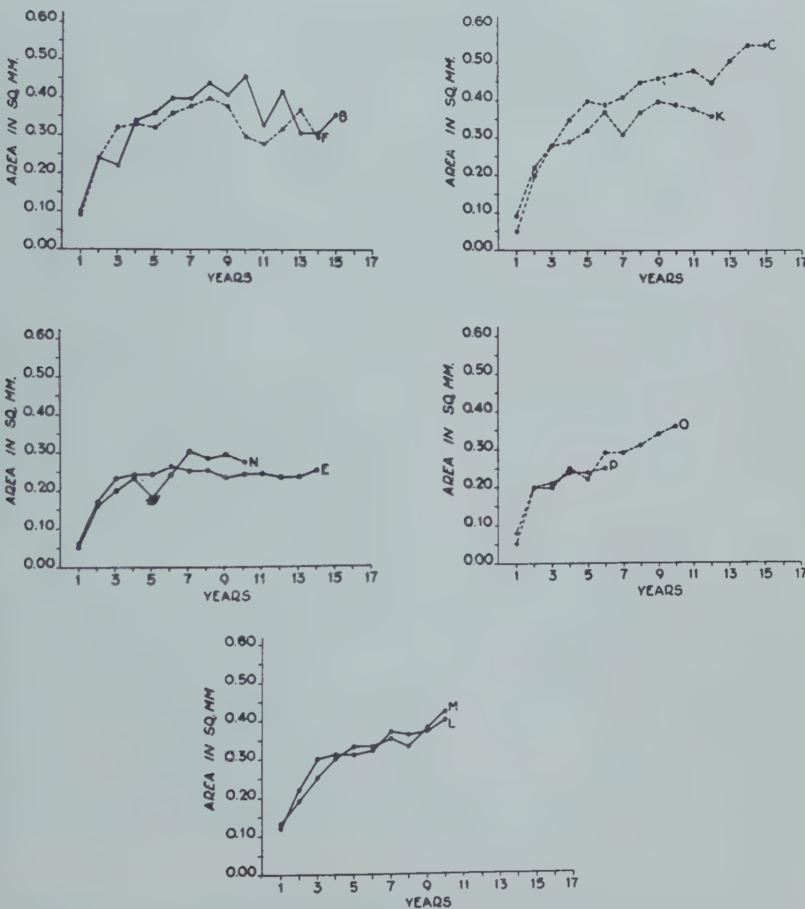

Fig. 6 Curves showing the total yearly area of 100 hairs for each of the siblings. Broken line, boys; solid line, girls.

birth is perplexing but may be related to the increase in area. Seibert and Steggerda ('42) observed a similar relationship between index and area within the length of single hair shafts. However, in this study the greatest drop

in index occurs during the 1st half of the 1st year of life and the greatest increase in size during the second half of the first year. The first year, the second, and perhaps the third appear to be a period of adjustment in which the most marked increase in area of all the years is preceded by a drop in index. Fluctuations in the cross-sectional areas of hairs may be attributed to several conditions.

The primary hair or lanugo of the fetus may persist after birth for several months (Pinkus, '27). It is believed to be entirely shed during the 1st year of life. This is followed by the secondary hair, vellus, which is the fine hair of post-natal life. In this study the high percentage of small hairs in the 1-month and the 7-month samples is probably due to some persistence of lanugo hairs during the 1st year of post-natal life and to small vellus hairs. The marked decrease in the percentage of small hairs during the second half of the first year indicates the transition from lanugo to vellus and the succeeding, but less marked, decreases indicate the transition of vellus hairs to the intermediate and terminal types. Most of the vellus on the head during the early years of childhood becomes coarser, presenting characteristics of terminal hair. Although this change may appear to the naked eye to affect all the hairs uniformly, there does persist a certain percentage of vellus hairs (6–25%, Danforth, '25), and all intergradations between the vellus and terminal hairs. This mixture of hairs in different stages of structural development has been demonstrated on the face also (Trotter, '22) and probably is a typical condition for most other parts of the body.

It has been shown that hair of certain regions of the body (leg, axilla, pubis), presents two periods during its life span: one of lengthening at a uniform rate followed by one of rest (Trotter, '24). This cyclic activity of the follicle is believed to apply to hair of all regions of the body. At approximately the time a hair is shed another appears and continues as did its predecessor through the two phases. There is evidence to suggest that, for some follicles at least, each suc-

cessive hair from a given follicle exceeds its predecessor in size. The range in size of hairs increases with the age of the individual. Since there are present in a given region of the scalp after the first few years of childhood hairs of all structural gradations, it would appear that certain follicles increase the size of successive hairs more markedly than others and, simultaneously, some follicles produce hairs of the same size for generation after generation. What stimulates a follicle to produce a terminal hair while the follicle close by persists in producing a vellus type of hair remains a question as Danforth ('25) has pointed out; that it is a normal condition cannot be denied. Had it been possible to measure succeeding generations of hairs from the same follicles throughout this study, it would be expected that after the second or third year of childhood the index would remain uniform and that the increase in area would be gradual and constant. The fluctuations could well be the result of a different proportion of terminal and vellus hairs and of the intermediate stages in the samples.

Seibert and Steggerda ('42) presented evidence to support Kneberg's earlier findings that a given hair varies in both size and index along its shaft. The greatest variation in size along the hair shaft of a white female past middle age in 6 samples was .00076 mm^2 and in index, 10 units. Kneberg's greatest variation was .00079 mm^2 in area and 27 units in index. Both are small when compared to the difference in size and index between different hairs, and are therefore not sufficient to explain either the increase in size during the 1st three years, the drop in index during the 1st two years, or the fluctuation in the later years seen in both size and index in this study.

The formulae for both index and cross-section area are based on the assumption that the outline of a cross-section of a hair is regular and symmetrical. In general, this regularity of outline is apparent, except in the few instances which were noted above.

Repeated efforts to improve the method of cross-sectioning hairs include those made by Fiala ('30), Kneberg ('35), Steggerda ('40) and Garn ('47). In general, hairs have been sectioned either after embedding in a firm medium or after packing in the Hardy microtome. The chief problem to be met is not the actual cutting of the hair but that the section be made in a plane at right angles to the shaft and that distortion through packing in the microtome be avoided. The chief error of the rotation method lies in the possibility of stretching the hair and thereby reducing its diameters. The close agreement resulting from the two methods applied to the hair of subject A may be interpreted as an indication of a minimum of disfigurement to the hairs and that the cuts were made at approximately right angles to the shaft. The variation between the two indices, 65.82 by the rotation method and 64.89 by the cross-section method, might be attributed to a slight flattening of the hairs when packed in the microtome or during the sectioning. The differences may be due, also, in part to the fact that the hairs measured by the two methods were not necessarily the same hairs but merely from the same sample.

Thus, fluctations from year to year seen in the index and area may be the result of the technique, the formulae, the fact that successive hair samples were not from the same follicles, that a hair shaft varies throughout its length, and to the change by many follicles in the type of hair produced. The relative uniformity in the earliest years indicates that the lanugo hair and its immediate successor, the vellus, are less variable than hair which is produced later.

SUMMARY

Sixteen White children of American parentage have provided samples of hair from the vertex of the head monthly since birth (the oldest is now 17 and the youngest 6). Fifty hairs from the 1st month's sample and from each 6 month sample thereafter have been measured for the greatest and

least diameters. From these diameters the index and cross-sectional area have been determined.

A comparison of index and of area determined by the rotation and cross-section methods shows only slight differences.

The index drops sharply during the 1st two years of life. However, following the 2nd year it is irregular with no uniformity in trend.

The size, or cross-sectional area, increases at a rapid and uniform rate during the 1st three years of life, and somewhat less rapidly and less uniformly thereafter.

Although the number of children is too small for a study of sex differences, the hair of the majority of the girls presents a lower index and a smaller size than the hair of the boys.

Among the subjects are 5 pairs of siblings: each pair shows similar trends in index and size with the most similarity between the identical twins.

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POSITION OF THE AUSTRALOPITHECINAE IN THE PRIMATE ORDER.— There cannot be any doubt that the discovery of the Taungs skull whose significance was immediately recognized by Raymond E. Dart when he found it in 1924, marks one of the great steps in the history of human paleontology. It is greatly to the credit of Robert Broom that he vigorously backed Dart against any attempt to minimize the importance of the find and himself began to search for more forms of this kind wherever he saw a chance. Thus we owe to Broom's indomitable spirit the knowledge of more types and the setting up of a new, well defined group of higher primates which are certainly closer to man than any of the fossil or living anthropoids.

However, despite the new finds and new facts, the exact place where the Australopithecinae have to be ranged within the primate order, particularly with regard to their relation to the hominids, is still open to discussion. In any case, one point is certain: the known Australopithecinae differ from anthropoids both living and fossil, by the character of their dentition . . . So far as other features of the Australopithecinae are concerned, they have only been compared with modern human forms, not with those of early hominids. The tacit assumption of such a limitation is apparently the idea that all features present in modern man must have passed through the same state of development as the anthropoids . . .

. . . As the matter now stands, it can be taken as granted that the Australopithecinae are apes so far as their general morphological character is concerned, but show in addition certain features which are found in man. The question is how these combinations can be explained. Undoubtedly the primary requisites are new and more complete finds. As to the critical point, it is my opinion that the human-like features of the Australopithecinae are signs of their past rather than of their "future." In other words, the features they share with man are those retained from an original stock when they, like typical anthropoids, acquired special differentiations. These led them away from the hominids whose differentiations went in other directions.— Franz Weidenreich. About the morphological character of the Australopithecinae skull. Robert Broom Commemorative Volume, 1948 (Special Publ. Roy. Soc. So. Africa), pp. 153–158.

NOTE

ANTHROPOMETRIC INSTRUMENTS

President Krogman reports that the firm of Siber Hegner & Co., Ltd., Zürich (New York office: 183 Madison Avenue) has been made international distributor of anthropometric instruments made by Gneupel Präzisions-Mechanik, Dübendorf (formerly P. Hermann, Zürich). To the prices listed below must be added a charge of 5% for packing, 12% for shipping and an import duty of 40–45%, depending on whether Customs classifies the instruments as scientific or non-scientific. Orders must be accompanied by 50% of the purchase cost, with the remainder due when the instruments are ready for shipment. Depending on the size of the order, delivery is promised within 4 to 6 months. The current rate of exchange is approximately 1 Swiss franc: 25c. Prices are subject to change without notice.

No.	*Description*	*Price (francs)*
1	Anthropometer, straight arms only, canvas case (see Martin's Lehrbuch, 1928, figs. 50, 52; pp. 129, 131)	415
2	Curved branches for anthropometer (ibid., fig. 53, p. 132)	90
3	Auricular height needle for anthropometer (ibid., pp. 132, 185)	53
4	Sliding caliper, 250 mm (ibid., fig. 49, p. 127)	110
5	Sliding caliper, 250 mm, Pöch type, (ibid., p. 128)	280
6	Spreading caliper, 300 mm, rounded tips (ibid., fig. 48, p. 125)	180
7	Spreading caliper, 300 mm, pointed tips	180
8	Spreading caliper, 600 mm, rounded tips (ibid., p. 126)	325
9	Spreading caliper, 600 mm, pointed tips	325
10	Steel measuring tape, 2 m (ibid., p. 133)	18
11	Canvas instrument bag, with sliding caliper (no. 4), spreading caliper, no. 6, tape no. 10 and dermatograph (ibid., fig. 83, p. 230)	370
12	Coordinate caliper, 300 mm (ibid., fig. 271, p. 592)	295
13	Coordinate caliper, large, Aichel (ibid., p. 592)	560
14	Attachable goniometer, Mollison type (ibid., figs. 56, 273, 274, 275, pp. 134, 594–596)	170
15	Tubular craniophore on tripod stand, with skull pincers (ibid., fig. 272, pp. 593, 603)	260
16	Mollison craniophore (ibid., fig. 281, p. 604)	225
17	Skull-height measuring instrument (Black) for use with no. 16 (ibid., fig. 284, p. 607)	180
18	Mollison craniophore and Black skull-height measuring instrument (no. 16 and no. 17 combined; ibid., fig. 284, p. 607)	405
19	Cubus craniophore with skull pincers (ibid., figs. 279, 280, p. 602)	460

20	Metal plate for use with no. 19 (ibid., fig. 280, p. 604)	35
21	Sight plate (Schlaginhaufen) for use with no. 19	55
22	Horizontal tracing needle, 30 cm (ibid., fig. 279, p. 601)	45
23	Horizontal tracing needle, 45 cm	60
24	Dioptograph, cubical, metal (ibid., fig. 8, p. 50)	1020
25	Dioptograph, rectangular, metal (ibid., p. 51)	1180
26	Diagraph (ibid., fig. 10, p. 54)	460
27	Parallelograph (ibid., fig. 468, p. 996)	650
28	Bone holder, for use with no. 27 (ibid., fig. 468, p. 996)	85
29	Breast molds, Lipiec type (ibid., p. 225)	120
30	Gauge for checking calipers (ibid., fig. 58, p. 136)	50
31	Palatometer (ibid., p. 600)	160

On request other anthropological instruments may be constructed against detailed specifications.

President Krogman urges that those interested in obtaining instruments communicate with him, since it may be possible to save money by ordering several sets at a time.

OESTERREICHISCHE GESELLSCHAFT FÜR ANTHROPOLOGIE, ETHNOLOGIE UND PRÄHISTORIE is the new name under which the Anthropologische Gesellschaft in Wien (1870) and the Wiener Prähistorische Gesellschaft (1914) have been combined since January 22, 1947. The latest Mitteilungen, vol. 73–77 (1943–1947), bears this new title. Part A (Anthropologie) of this volume contains the following articles:

Ehgartner, Wilhelm — Der spätrömische Friedhof von Oggau, Burgenland. Pp. 2–32 with two plates.

Pacher, Helga Maria — Drei Maori-Schädel und ihre Stellung innerhalb der biologischen Probleme der Südsee. Pp. 33–54 with three plates.

Weninger, Margarete — Zur Vererbung der Hautleistenmuster am Hypothenar der menschlichen Hand. Pp. 55–82 with 4 plates.

BIBLIOGRAPHY ON THE NEGRO.— In a recent number of the Boletín *Bibliográfico de Anthropología Americana* (vol. 10, 1948, pp. 121–132), Juan Comas has recompiled and systematized articles in the *American Journal of Physical Anthropology* dealing with somatic studies on the American Negro. The period covered is from 1918 to December, 1947. A total of 170 articles are listed under 9 headings: General, somatometrics, cranio- and osteometrics, development and growth, tissues and senses, myology, blood and blood vessels, internal organs, and miscellaneous. There is a separate alphabetical listing of authors.

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